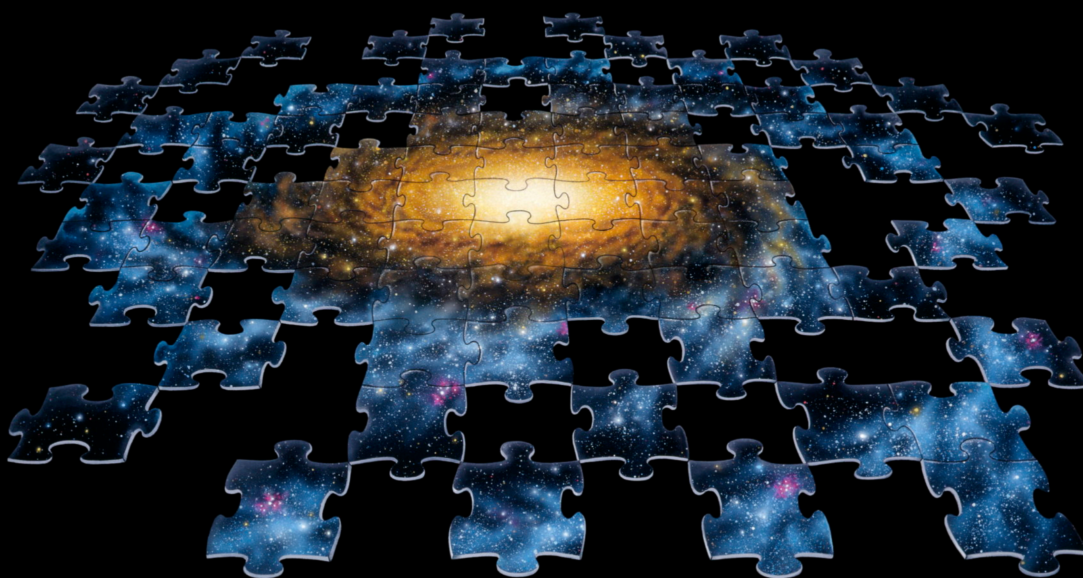
On the Geometry of Time in Physics and Cosmology

and the fall of the canonical cosmological model



Scientia vincere tenebras

"Conquering darkness by science"

Alexander F. Mayer

"Science is not about status quo. It's about revolution."

– Leon Max Lederman

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On the Geometry of Time in Physics and Cosmology and the fall of the canonical cosmological model

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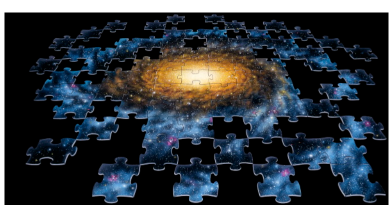

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PREFACE

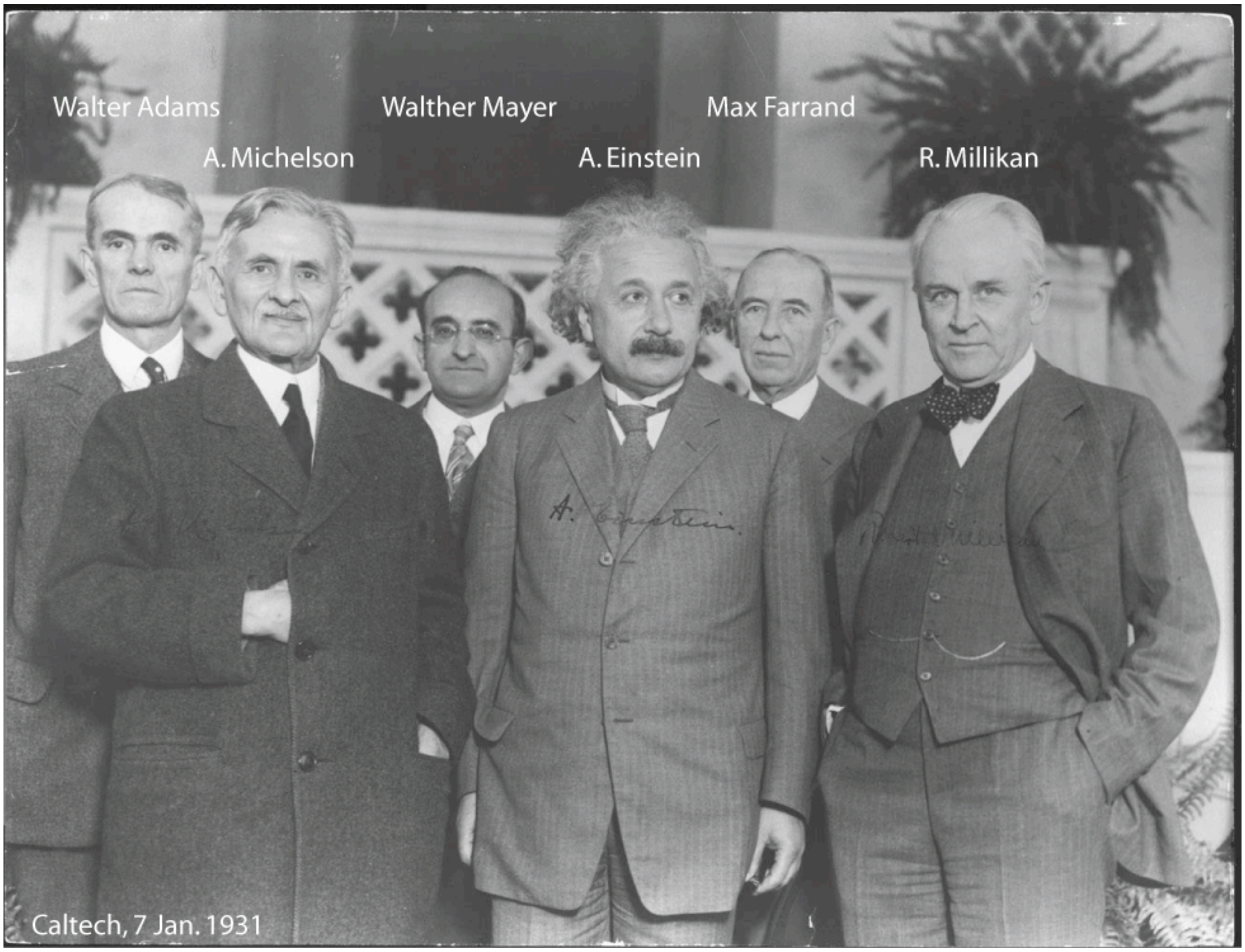
The key innovation introduced in this book is a revolutionary model of time in the context of relativity. It is aimed at a broad technically educated audience that spans the spectrum of academic and industry professionals to advanced university undergraduates, select science journalists and amateurs in physics, mathematics, astronomy and other physical sciences. Like the Copernican Revolution, which replaced the Earth as the center of the Solar System model with the Sun, this new way of thinking about time is simple and obvious in hindsight. It is based on a direct physical interpretation of Minkowski spacetime geometry, rather than the conventional wisdom that Minkowski's geometric foundation for special relativity introduced a mere "mathematical convenience." The simple step of reinterpreting Minkowski's mathematics as an immediate description of underlying physical reality, instead of mistakenly treating it as nothing more than a helpful mathematical abstraction, removes a fundamental impasse to progress in theoretical physics. In this book, graduate students and young investigators in physics will find fruitful new avenues of inquiry providing opportunities to contribute to a modern revolution in physics similar to the revolution of a century ago.

Sections 1–14 introduce the concept of geometric cosmic time and deal primarily with cosmology. It is shown that recent galaxy redshift survey data are inconsistent with the Hubble Law and that a quantitative model of geometric cosmic time is consistent with these data. This model also implies that the supernovae redshift-luminosity curve was mistakenly interpreted as a sudden onset of accelerating cosmic expansion. *Sections 15–24* discuss symmetric relativistic *transverse gravitational redshift* (*TGR*), a ubiquitous empirical phenomenon implying an insufficiency in general relativity because the observable is unmodeled by the Einstein field equations. According to one of his former students who spoke with me, Richard Feynman reportedly knew of *TGR* circa 1965, yet he never discussed it in the literature as he was apparently unable to develop more than a naïve initial theoretical model. Progress has been made by identifying a simple error in the way general relativity models time. A new equation that rests on first principles is able to accurately predict the magnitude of the phenomenon manifesting as the observed unexplained variable excess redshift of stars, being most pronounced for white dwarfs. *Sections 25-29* revisit cosmology, leveraging on the new insights in the prior sections concerning gravitational physics. *Sections 30–36* discuss relativistic energy and introduce the concept of the momentum wave in quantum mechanics, which provides a path to elegantly solving several outstanding problems in physics, including quantum gravity.

After adopting the model of time introduced herein, it is certain that within just a few years all physical scientists will think to themselves, "How could we have ever thought otherwise?" Yet, upon being confronted with a new idea, there is a prevalent tendency for people to initially think, "That is not the way everyone thinks about it," with the tacit assumption that the conventional wisdom (i.e., textbook dogma) is correct and unassailable. While building on the past is essential to progress in physical science, a bright young lady exhibiting the wisdom of youth at age ten once said to me, "Knowing stuff gets in the way of learning stuff." Accordingly, it is also true that the assumption of knowledge or an emotional need to be knowledgeable in order to live up to an academic title can block intellectual progress. New understanding generally arises from a place of *not knowing* and questioning the authority of experts, including oneself. Perhaps one of the reasons that innovative thinking in physics has consistently been associated with youth is not the intellectual capacity for innovation, but the emotional state of being open to not knowing. Therefore, I encourage my readers to be youthful in their approach to reading this book. Being critical in the context of defending what is assumed to be known cannot lead to new understanding. Rather, the path to new knowledge and the exhilarating feeling of new understanding is the willingness to be critical of what is assumed to be known in the process of evaluating new ideas presented for consideration.

Ultimately, theoretical physics is not about the individual process of developing understanding, but the results of that process as determined by repeatable empirical observations that are consistent with qualitative and quantitative predictions. While the new ideas and unorthodox methods introduced herein may at first seem simplistic to those expecting a more esoteric mathematical approach, the predictive results speak for themselves. Parsimonious (rather than jejune) theory yields predictions that correlate with existing unexplained observations. Moreover, every new idea and empirical prediction appearing in this book ultimately rests on a single first principle: the invariance of the speed of light in vacuum. Confidence in each of the new ideas presented is inspired by the realization that if the speed of light in vacuum is invariant, then it must also be true (it logically follows) that the new idea is also true.

So was he [Einstein] a saint?, I asked Balázs. “No,” he replied firmly. “He was better than that — he was human.”
– Graham Farmelo   (Nándor Balázs assisted Einstein for one year at Princeton circa 1952. He died in 2003.)



Courtesy Smithsonian Institution Libraries. Text overlay from Ze’ev Rosenkranz, *The Einstein Scrapbook* (2002), p. 132.

Although Einstein was the greatest genius of the twentieth century, many of his groundbreaking discoveries were blighted by mistakes, ranging from serious errors in mathematics to bad misconceptions in physics and failures to grasp the subtleties of his own creations.

– Publisher’s synopsis from the front jacket cover of

Hans C. Ohanian, *Einstein’s Mistakes: The Human Failings of Genius,*
(W. W. Norton & Co., New York, 2008).

Hans Ohanian is the author of several physics textbooks.
He studied relativity with John Wheeler at Princeton University.

…we might say that an ordinary mistake is one that leads to a dead end, while a profound mistake is one that leads to progress. Anyone can make an ordinary mistake, but it takes a genius to make a profound mistake. – Frank Wilczek in *The Lightness of Being,* (Basic Books, 2008), p. 12.

Mathematician Georges Lemaître (left), astronomers Edwin Hubble (center) and John C. Duncan (right) appear together in this photograph chronicling the Catholic priest's **1925** visit to Mt. Wilson Observatory.

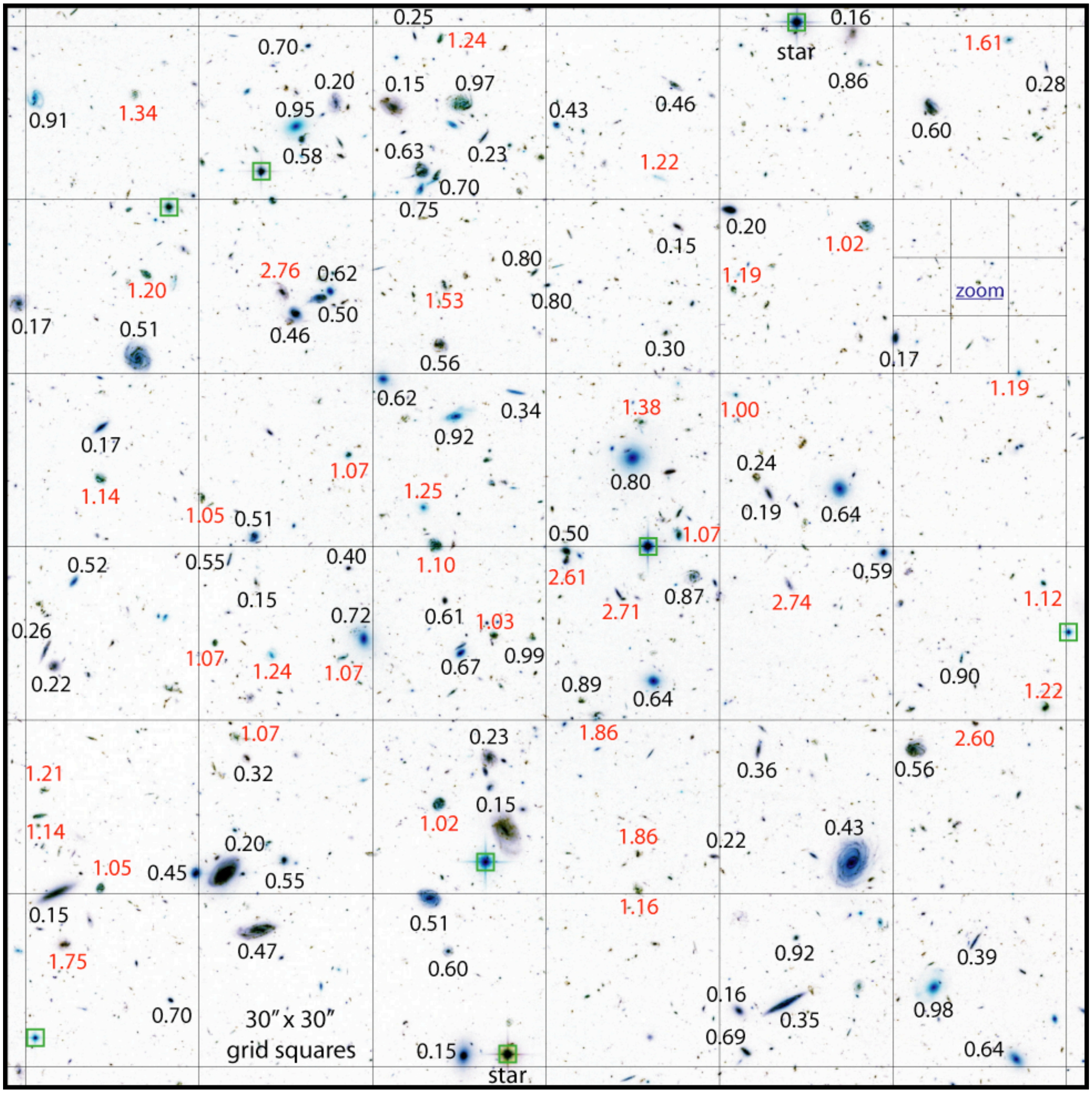
Associated Historical Timeline

- 1920 – Lemaître receives a Ph.D. in mathematics from the Catholic University of Louvain.
- 1922 – Lemaître asserts in writing his belief that "as *Genesis* suggested it, the Universe had begun by light."[1, 2, 3, 4]
- 1923 – Lemaître is ordained a Catholic priest following seminary at the Maison Saint Rombaut.
- 1925 – Lemaître accepts a position as lecturer at the Catholic University of Louvain.
- **1925 – Lemaître visits Edwin Hubble at Mt. Wilson Observatory (photo).**
- 1926 – Lemaître submits paper that first proposes a suddenly created expanding Universe and the "Hubble law."
- 1927 – *Annales de la Société scientifique de Bruxelles* publishes this paper entitled, "A Homogeneous Universe of Constant Mass and Increasing Radius accounting for the Radial Velocity of Extra-galactic Nebulœ" in French.
- 1927 – Lemaître receives a Ph.D. in physics from MIT.
- **1929 –** In *PNAS*, Hubble claims an expanding Universe with $H_0 = 500\ km/s/Mpc$; **Lemaître is not referenced.**
- 1931 – *MNRAS* (a British journal) publishes an abridged English translation of Lemaître's 1927 Belgian publication.
- 1931 – Lemaître in *Nature*: "...the beginning of the world happened a little before the beginning of space and time."[5]
- 1958 – *Astrophysical Journal* publishes the first major correction to "Hubble constant": $H_0 = 75\ km/s/Mpc$ (A. Sandage).
- **1998 –** Supernovae data interpreted as a sudden onset of *accelerating expansion* initiates a ***scientific crisis*.**

186” x 186” negative image of the Hubble Ultra Deep Field (HUDF)

Cropped from original (200” x 200”) telescope source image with ~10^4 objects.

This Hubble Telescope image of nearly 9,000 galaxies implies an average population of about 225 galaxies per 30" x 30" grid square. Here, 115 of the measured galaxy redshifts are labeled.



Every point of light in the image is believed to be a galaxy, except for the eight foreground stars (green squares). Positive Hubble Telescope source image courtesy NASA, ESA, S. Beckwith (STScI) and the HUDF Team.
Redshifts shown ($z \geq 1$ in red) reference the AHaH program (Mechtley, Windhorst, Cohen & Will, 2008).
See http://www.asu.edu/clas/hst/www/ahah/ and http://biphenyl.org/papers/mechtley2008.pdf

Also see S. Beckwith *et al*., “The Hubble Ultra Deep Field,” http://arxiv.org/abs/astro-ph/0607632

PREAMBLE QUOTATIONS

Unfortunately, a study of the history of modern cosmology reveals disturbing parallelisms between modern cosmology and medieval scholasticism; often the borderline between sophistication and sophistry, between numeration and numerology, seems very precarious indeed. Above all I am concerned by an apparent loss of contact with empirical evidence and observational facts, and, worse, by a deliberate refusal on the part of some theorists to accept such results when they appear to be in conflict with some of the oversimplified and therefore intellectually appealing theories of the universe.

– Gérard de Vaucouleurs (1918–1995)
"The Case for a Hierarchical Cosmology,"
Science **167**, 1203 (1970).

Δ

The leading idea which is present in all our researches, and which accompanies every fresh observation, the sound which to the ear of the student of Nature seems continually echoed in every part of her works, is —

Time! — Time! — Time! *

* It is very remarkable that, while the words *Eternal*, *Eternity*, *For ever*, are constantly in our mouths, and applied without hesitation, we yet experience considerable difficulty in contemplating any definite term which bears a very large proportion to the brief cycles of our petty chronicles. There are many minds that would not for an instant doubt the God of Nature to have existed *from all Eternity*, and would yet reject as preposterous the idea of going back a million of years in the History of *His Works*. Yet what is a million, or a million million, of solar revolutions to an Eternity?

– George Poulett Scrope, *The Geology and Extinct Volcanos of Central France*, (1858), p. 208; Google Books: http://tinyurl.com/5t6ew2

Δ

People think the problem with models is that they are limited by our minds, but the greater problem is that our minds are limited by our models.

– Kenneth G. Gayley (2008)

Δ

★ It's the things that we most take for granted that have the tendency to come back and bite us when it really matters. The nature of space and time is generally taken for granted. But our assumptions about them seem to be inconsistent and as a result, if we are honest, theoretical physics is currently derailed at its very core.

– Shahn Majid, in the section "A Hole at the Heart of Science,"
On Space and Time, (Cambridge University Press, 2008), p. 58.

Δ

★ In this world, time is a local phenomenon. Two clocks close together tick at nearly the same rate. But clocks separated by distance tick at different rates, the farther apart the more out of step. What holds true for clocks holds true also for the rate of heartbeats, the pace of inhales and exhales, the movement of wind in tall grass. In this world, time flows at different speeds in different locations.

– Alan Lightman in *Einstein's Dreams,* (Vintage Books, 2004), p. 120.

Δ

A theoretical construction represented by elementary geometry and understood as an object of immediate geometrical experience leads to a strong expectation of internal consistency, more than an analytical derivation does for the outsider.

– Dierck-Ekkehard Liebscher in *The Geometry of Time,* (Wiley, 2005), p. 1.

On the Geometry of Time in Physics and Cosmology

Alexander F. Mayer

The geometric properties of time arising from insights introduced by Hermann Minkowski are discussed. A geometric model of time yields a simpler and more natural explanation of relativistic temporal effects than prevailing ideas and better explains astrophysical empirical observations, including the apparent accelerating expansion of the Universe. It is shown that new accurate and corroborating empirical data from the two largest recent galaxy redshift surveys (2dF and SDSS) is inconsistent with the standard cosmological model, yet provides robust empirical support for a revised model based on temporal geometry arising from the principles of relativity. ***This dissertation also introduces several innovative and illuminating ideas related to special relativity, general relativity and quantum mechanics.***

1. HISTORICAL BACKGROUND

In this first decade of the 21st century, two independent mapping projects in the form of large galaxy redshift surveys (2dF in Australia and SDSS in the U.S.) have provided new corroborating data that must forever alter our understanding of the physical Universe. Similarly, the prospect of an accurate world map may have in part motivated the Greek philosopher-mathematicians to abandon the ancient world's model of a 'flat' Earth suggested by the illusory experience of unidirectional gravity. The key abstract concept that was required for the historical transition from a naïve to an accurate geometric model of the Earth was the understanding that the local vertical (i.e., the altitude 'dimension' of space) is not parallel over the extent of Earth's surface, in spite of persuasive superficial experience. An accurate cosmological model requires a similar paradigm shift as concerns the geometric relationship between space and time for the Cosmos.

When Albert Einstein's concept of "curved spacetime" was applied to cosmology in 1916–1917, it was first suspected that the totality of cosmic three-dimensional space manifests as a finite yet boundaryless volume, which is similar in topological properties to the familiar finite yet boundaryless surface area of a 2-sphere ($S_2 = 4\pi r^2$).[6,7] Although a finite boundaryless volume is mathematically trivial, it is something that is experientially inaccessible and therefore difficult for most people to visualize or imagine as something physically real. Einstein first rationalized the idea that maximal extension of any local line segment in physical cosmic space must produce a finite closed geodesic curve. In *real projective space*, the maximum possible distance of separation between two points is *pi*/2 times the effective spatial radius of the Universe (i.e., the unique cosmic antipode to any galaxy is modeled at this distance as measured over a connecting geodesic pointing away from that galaxy in any arbitrary local direction).

At about the same time that Einstein proposed his relativistic theory of gravity, Vesto Slipher, Director of the Lowell Observatory in Flagstaff, Arizona, first discovered the preponderance of redshifts for the spiral nebulae.[8,9,10] More than a decade later, Slipher's protégé, Edwin Hubble, authoritatively announced in a famous 1929 paper that the galactic redshifts were indicative of a recessional radial velocity.[11] According to his astrophysical measurements, the relationship between the redshift of a galaxy and its distance (H_0) was linear, amounting to an initially proposed value of 500 *km*/*s*/*Mpc*. Hubble's paper, which appeared in the prestigious *Proceedings of the National Academy of Sciences*, clearly suggested that reliable empirical evidence implied that the Universe was expanding, apparently initiated by a kind of primordial explosion. According to experience, gravity is an exclusively attractive force, so a phenomenon that somehow prevents general cosmic gravitational implosion over time is required to explain the observed Universe. An expanding Universe appealed as a natural solution to this problem.

The idea that the Universe had a distinct beginning is credited to a Catholic priest. Ordained in 1923 at age 29, Abbé Georges Lemaître's cosmic creation idea was first published in the same year he earned his Ph.D. in astrophysics from MIT (1927). A precursor 1921 essay, *God's First Three Declarations*, was self-described as "an attempt to interpret scientifically the first verses of *Genesis*."[12] Later he reportedly summarized his ideas as "the Cosmic Egg exploding at *the moment of Creation*."[13] It is evident that Lemaître's concept of a suddenly created expanding Universe was founded on an influential personal interpretation of the Hebrew biblical creation myth that was extended to be cosmological in scope.

Lemaître met with Hubble at Mt. Wilson in 1925, which is documented by a photograph of the two together at the observatory (see preceding page v). In the following year, Lemaître submitted a paper discussing his idea of an expanding Universe, which was published in 1927.[14] This paper was not widely read as it was written in French and appeared in an obscure Belgian scientific journal. An abbreviated English translation of this seminal paper, "A Homogeneous Universe of Constant Mass and Increasing Radius Accounting for the Radial Velocity of Extra-galactic Nebulæ," appeared in *Monthly Notices of the Royal Astronomical Society* two years after Hubble had established his reputation for discovering cosmic expansion in 1929.[15] It is typically assumed that the idea of cosmic expansion was initiated by unbiased empirical observation of galaxy redshifts, yet evidence suggests that Hubble got his ideas from the priest as early as their 1925 meeting and that his linear relation between galaxy redshift and distance passing through the origin of the graph was an unwarranted subjective interpretative fit to Lemaître's expanding universe theory. Hubble had a peculiar habit of fabricating impressive personal achievements, so it is not unreasonable to suspect that Hubble's 1929 paper may not have been as original as it may have seemed.[16]

It took three decades for astronomers to accept that Hubble's original proposal of an expansion constant of $H_0 = 500$ *km*/*s*/*Mpc* was impossible, as this value would imply that the Universe was considerably younger than the already well-established minimum geologic age of the Earth. The correct value for the "Hubble constant" (H_0) was estimated to be about an order of magnitude lower.[17,18] This large correction to Hubble's original quantitative analysis of the astrophysical data was apparently not considered a threat to his qualitative interpretation of that same data. The initially controversial idea of the expanding Universe became popularly known as the Big Bang theory, although this moniker was originally intended by its author, famed British astronomer Sir Fred Hoyle, to mock what he felt was a ludicrous idea.

Penzias and Wilson's 1965 discovery of the cosmic microwave background radiation (CMB) lent credence to the theory as this radiation was assumed to prove the predicted existence of the ubiquitous cooled remnants of heat generated by a primordial cosmic explosion.[19,20] Also, it is known that the stellar nucleosynthesis process in stars of all sizes results in a net consumption of deuterium (^2H) rather than its production. The measured cosmic abundance of ^2H and other light elements suggests a non-stellar source of intense heat and pressure, further lending credence to the Big Bang and its cosmic primordial phase. The late 20th-century surge in high technology enabled more accurate redshift-luminosity (distance) measurements. In 1998, astronomers were shocked when the interpretation of the new measurements implied an accelerating expansion rather than one that was anticipated to be slowing down due to the effects of gravity.[21] This interpretation requires a mysterious and inexplicable cosmic energy source to fuel the phenomenon, which was dubbed "dark energy," ironically reminiscent of the Dark Ages.

Over the 20th century, the Big Bang theory evolved to become a major cornerstone of modern science, yet the fact that the theory requires an incredible event representing *the beginning of time* presents one of its greatest scientific challenges. No satisfactory explanation exists of how an event that produces spacetime and the physical Universe can occur when spacetime (and so time itself) does not exist prior to this purported event. The purported singularity in space and time at $T = 0$ defies logical analysis.

> In the tradition of *Amadeus* and *A Beautiful Mind*, [the screenplay] "Hubble" is the magnificent story of one of history's greatest and most flawed geniuses and the even more magnificent universe he sought to map. In 1931, Edwin Hubble became the most famous man in the world. He was heralded as the greatest astronomer since Galileo. His discoveries had an irrevocable impact on both Einstein's Theory of Relativity and religious interpretations of the origins of heaven and earth. But Hubble was a haunted man, dogged by mysterious secrets from the past and by enemies that threatened to destroy everything. How could a man who spoke with a British accent, wore a cape, and carried a cane be from Missouri? Why did none of his stories of his past match the claims of others? How could his wife Grace knowingly perpetuate all of this? Driven by intense ambition and a longing for something that was lost long ago, a man whose life is cloaked in pathological lies paradoxically discovers [what is purported to be] one of science's greatest and most enduring truths.[22]

It is an odd fact of history that the foundation of 20th-century cosmology (the veritable foundation of all science and even of modern mankind's pervasive scientific ontology) is the product of an ecclesiastic with an obvious bias (Lemaître) and an inveterate fabulist (Hubble). In this light, the forthcoming revelations based on new high-quality astrophysical data and accurate predictive theory are not so very surprising.

2. GALAXY REDSHIFT SURVEY DATA

Fig. (1) presents data from two galaxy redshift surveys. The Two Degree Field Survey (2dF) employed the Anglo-Australian Telescope at Siding Spring Observatory in Australia. Its database, completed in 2003, contains high-quality spectra for over 200,000 objects in the southern sky. The Sloan Digital Sky Survey (SDSS) is being conducted from the Apache Point Observatory in New Mexico. SDSS is in the process of determining the fundamental observational parameters for about 900,000 galaxies and 100,000 quasars over about one-quarter of the northern sky. Data Release 7 (DR7) of the SDSS database, published in November 2008, includes high-quality spectroscopic data for over 800,000 galaxies and quasars.

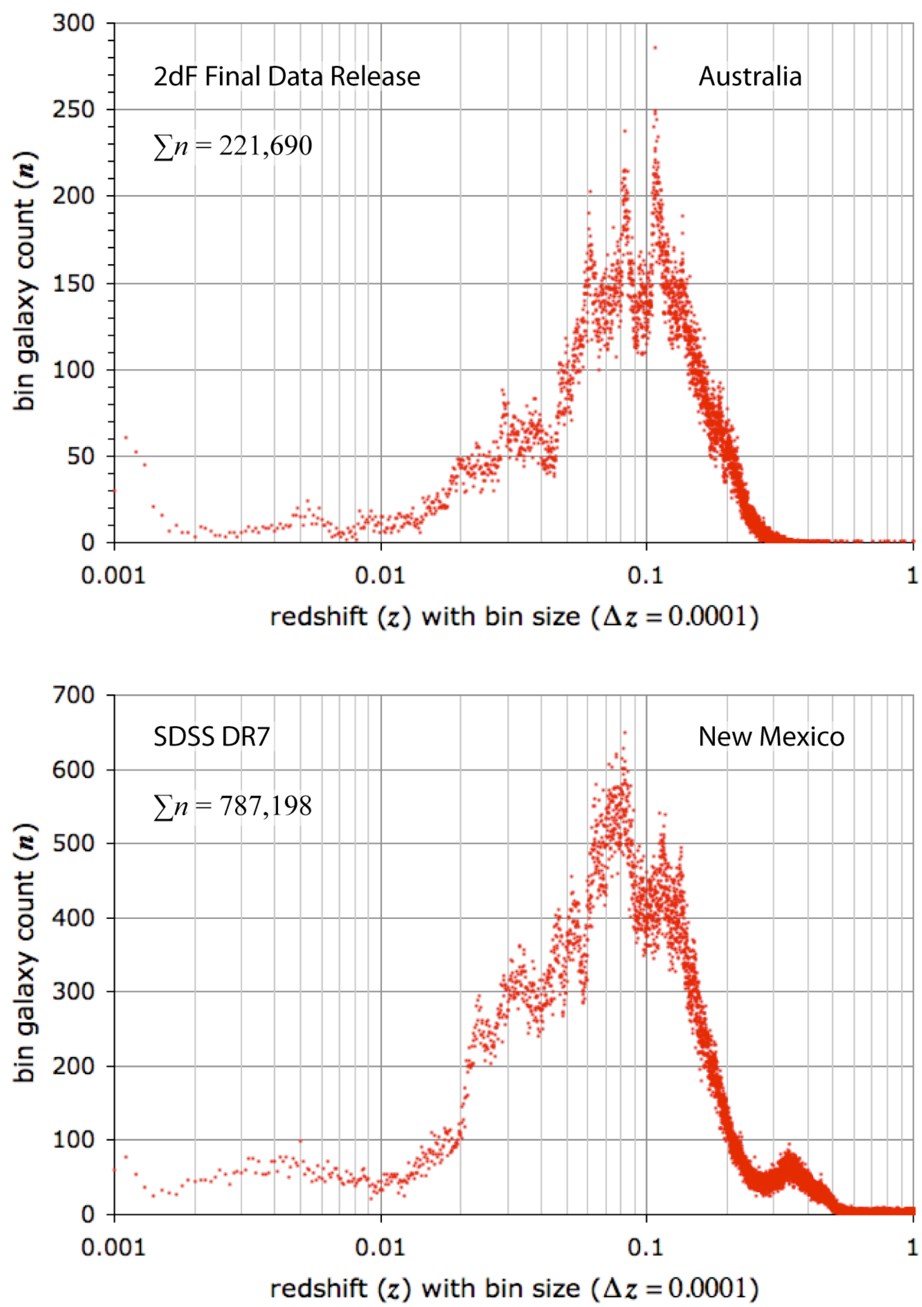


Figure 1 | Data from the 2dF (Australia) and SDSS (New Mexico) galaxy redshift surveys.
The rise in bin count at low redshift (<0.001) is due to false objects misidentified as distinct galaxies.

The two histograms in Fig. (1) were created in a very simple way. Spectroscopic data selected for high quality was sorted into bins (represented by the dots) having a Δz of 10^{-4} and coordinates (z, n) where n is galaxy count. Consequently, each graph shows the galactic density trend in redshift space. The total number of galaxies plotted in each graph is indicated as Σn. The graphed SDSS data can be easily recreated directly from the online SDSS database using the following Structured Query Language (SQL) statement.

http://ExecSQL.info/sdss1.htm

```
SELECT
        ROUND(z, 4) AS z
,       COUNT(1) AS n
FROM
        SpecObj
WHERE
        objType IN (0, 1)            /* galaxies and QSO only */
AND     zStatus IN (3, 4, 6, 7, 9)   /* selected for high quality */
AND     z >= 0.001                   /* mostly removes misidentified double stars */
GROUP BY
        ROUND(z, 4);
```

The graphed 2dF data requires an intermediary database.

http://www.mso.anu.edu.au/2dFGRS/ (see "Data Release" link)

```
/* this query must be performed on the online 2dF database */
/* select option "e-mail URL of compressed text file" (returns 233,251 rows) */
/* (extnum = 0) implies primary FITS extension (best spectrum) */

SELECT z_helio, alpha, ra2000, delta, dec2000
        FROM TDFgg
WHERE extnum = 0 AND quality >= 3;    /* (quality >= 3) reduces row count from 382k to 233k */

/* this query must be performed on a local database table after importing the above data */
/* the online 2dF MiniSQL (mSQL) database does not support the COUNT() function */
SELECT
        ROUND(z_helio, 4)
,       COUNT(1) AS n
FROM
        TDFgg_local
WHERE
        z_helio >= 0.001       /* mostly removes misidentified double stars */
GROUP BY
        ROUND(z_helio, 4);
```

According to the two graphs, these two distinct surveys exhibit nearly identical qualitative results. Because they were conducted in opposite hemispheres, the surveys incorporate data on different sets of galaxies far removed from one another. Because different teams using different instruments conducted the two surveys, correlations between the data sets are certain to reflect underlying empirical reality. Due to the inherent accuracy of spectroscopy and the statistical nature of the data, these surveys represent a uniquely objective astrophysical insight into cosmology. Their corroborating galaxy maps, which have been made available only recently, provide conclusive empirical evidence that the conventional cosmological model (i.e., the Big Bang theory) incorporates fundamental errors of empirical interpretation in similar fashion to the misbegotten cosmology put forward by Aristotle in his treatise, *On the Heavens*, circa 350 B.C.E.

It is clear that the spatial volume of the bins must increase from redshift 0.001 to 0.01, yet the number of selected bright galaxies per bin remains nearly constant over this range. This observed drop in galaxy space density provides strong confirmation (in the nearby Universe) of Benoit Mandelbrot's pioneering assertion in his 1977 book, *Fractals: form, chance, and dimension*, that galaxies are fractally distributed.[23] When the fractal dimension of a physical structure is less than 3, the number density of points decreases when the volume of space under consideration is increased. This is exactly what is observed.

The Copernican Principle or "mediocrity principle" is the rational notion in the philosophy of science that there is nothing unique about the Earth's physical location in the Cosmos. Consequently, the astronomical perspective of the large-scale Cosmos out to the limits of observation as seen from Earth is understood to be essentially the same as from a planet in any other galaxy. The cosmological principle is

an extension of the Copernican Principle arising from the simple consideration that gravity is a conservative force that naturally produces isotropic symmetry. Properly formulated, the cosmological principle states that looking in any direction in space from the vantage point of any galaxy, the large-scale Universe looks similar. Succinctly, this means that no observer may look out from a galaxy located at a misconceived "edge" of the Universe where in one direction can be observed many other galaxies and in the other a limitless void bereft of galaxies. While galaxies clearly have a fractal distribution on a large local scale, this restriction on the physical nature of the Universe (i.e., that it is boundaryless) implies that at some observational distance, galaxies must transition to a homogenous and isotropic distribution.

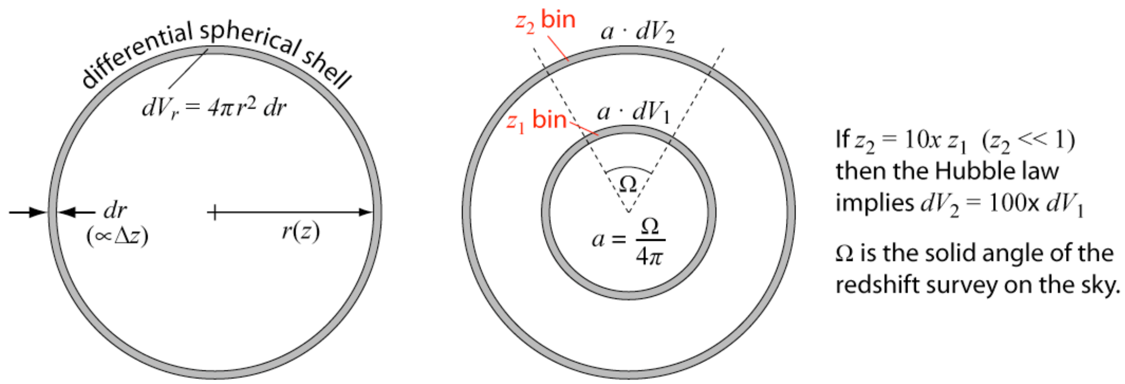


Figure 2 | Volume of a differential spherical shell of thickness Δz. For a given solid angle on the sky (a survey region), the observed volume fraction (a) is independent of distance. Assuming that the function $r(z)$ is linear, the volume of space represented by bins of identical Δz (i.e., identical dr) increases as the square of the spatial distance represented by the characteristic redshift (z) of the bin.

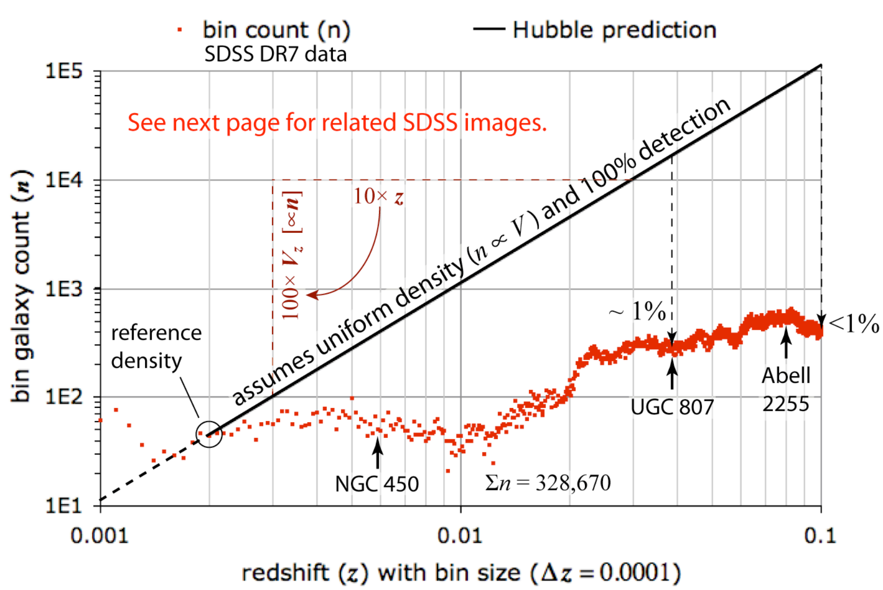


Figure 3 | Observed low-z galaxy population trend vs. Big Bang prediction (100% detection). A redshift of $z = 0.01$, which is conventionally interpreted as a distance on the order of 10^8 light years, is about the estimated radius of the local supercluster (Virgo). SDSS observes internal detail of typical galaxies within this distance. The SDSS optical negatives shown on the next page imply that within order $z < 0.1$, *at least* 10% of survey-selected bright galaxies are counted within this redshift distance. The huge deficit of galaxies in the survey in the range of redshift shown here as compared to the Hubble prediction cannot be attributed to galaxies dropping out of the sample.

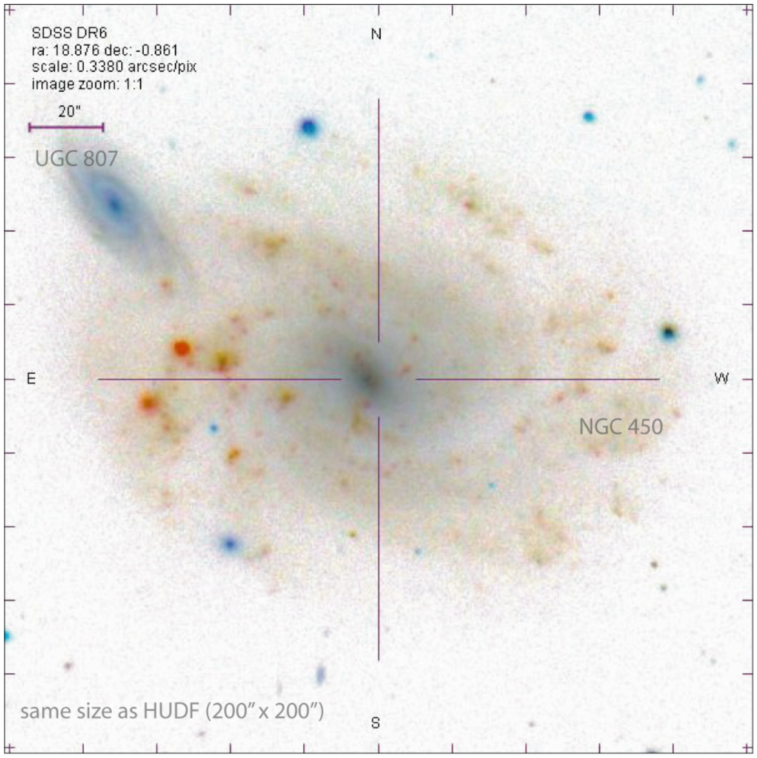


Figure 4 | SDSS negative image (20" ticks) of the two galaxies referenced in Fig. (3).

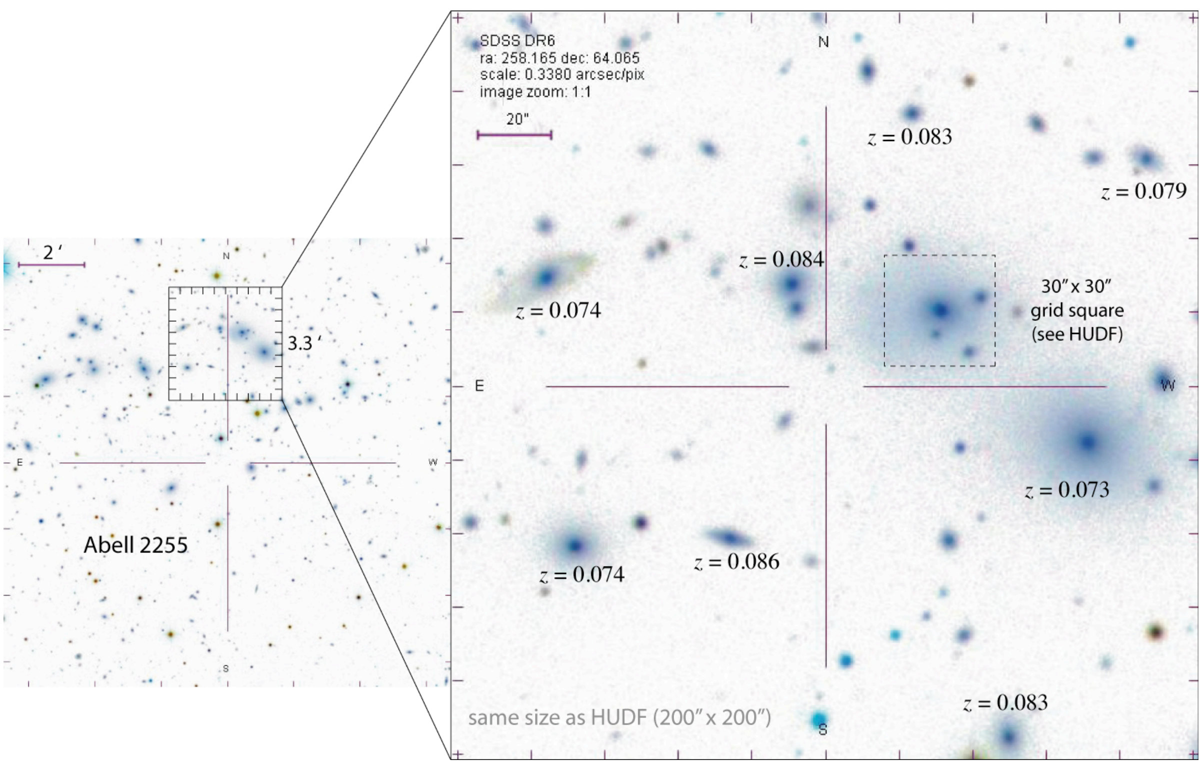


Figure 5 | SDSS negative (20" ticks) of galaxy cluster Abell 2255 referenced in Fig. (3).

A slice of redshift (Δz) represents a spherical shell in space. The spatial thickness of this shell (dr) is the same at any redshift z within a range where the relationship between redshift and distance is linear. *Assuming a linear relationship*, the volume of space enclosed by these differential shells will increase as the square of the redshift (i.e., the square of the distance). Consequently, according to the "Hubble law" and the simple geometry in Fig. (2), the spatial volume of a redshift bin plotted at $z = 0.015$ in Fig. (3) is approximately two orders of magnitude larger than a $z = 0.0015$ bin plotted in the same graph. Identically, the redshift range ($0.01 \leq z \leq 0.1$) ostensibly represents a change in bin volume by a factor of 100.

With no possibility of huge numbers of selected bright galaxies having dropped out of the sample, bin galaxy counts in Fig. (3) remain constant between $z = 0.001$ and 0.01, representing an apparent drop in galaxy space density over this redshift range by two orders of magnitude. In the range $z = 0.001$ to 0.1 shown in Fig. (3), the linear redshift-distance relationship prescribed by the "Hubble law" implies that bin volume increases by three orders of magnitude, yet the empirical bin galaxy count increases by just one order of magnitude. As discussed in the Fig. (3) comments, this apparent drop in galaxy space density according to the survey data cannot be attributed to observational effects; it cannot be that the extreme majority (~ 99% – 99.9%) of survey-selected bright galaxies are of insufficient apparent luminosity to be counted as distance increases within the redshift range shown. Regardless of an obvious modeling error in the redshift-distance relationship, the observed apparent decrease in galaxy space density as the redshift survey bin volume increases to $z = 0.01$ suggests a fractal distribution of galaxies in the nearby Universe as implied by a previously published more complex geometric analysis of galaxy clustering in space.[24]

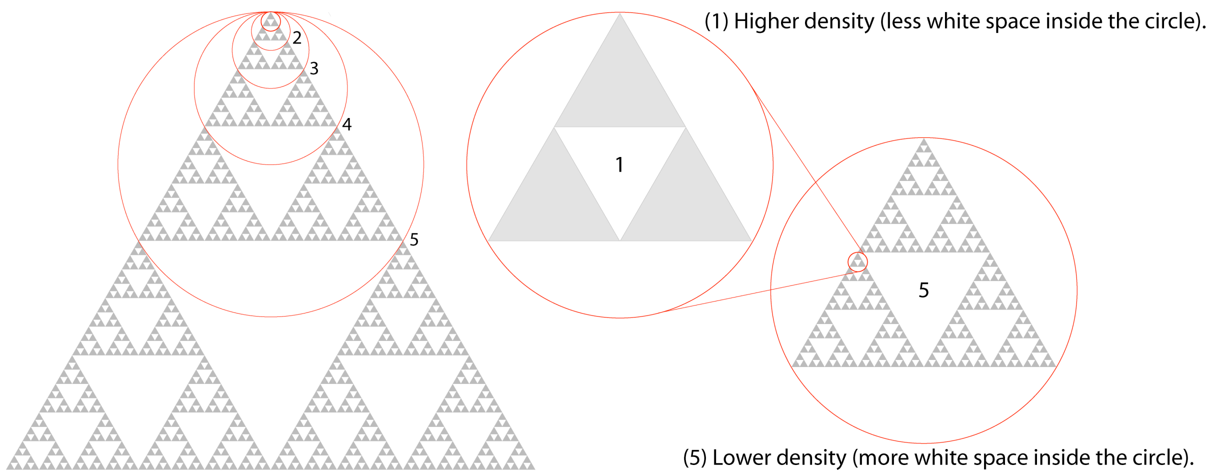


Figure 6 | A Sierpiński triangle formed by 6 "cluster-size" iterations exhibits large voids. This fractal has Hausdorff dimension $D = \log(3)/\log(2) \approx 1.585$, as it is constructed with three copies of the unit object, producing a new self-similar object scaled up by a factor of 2. This simple illustrative example of fractal geometry in two dimensions clearly shows the characteristic increase in the space density of fundamental unit objects (smallest triangles) as the area under consideration (red circles) decreases. Also, in contrast to a homogeneous distribution of objects (e.g., gas molecules), large voids are a fundamental feature of a fractal distribution of objects. The term "supervoid" has been coined for the observed *WMAP cold spot* in Eridanus, an apparent void of cosmological scale.[25]

Assuming that the higher redshift data ($z > 0.01$) graphed in Fig. (1) is reasonably accurate, the closely matching spikes and dips in the two graphs show cosmically global variations in galactic space density. Also, the matching overall shape of the two curves, which exhibits a dramatic rise at about $z = 0.01$, a peak at about $z = 0.1$, and a sharp decline thereafter, is clearly of cosmological significance. The sustained sharp rise in the curve suggests onset of a rapid increase in the volume of space with redshift (dV/dz); larger bins can contain more galaxies. The sharp decline in the curve after the peak must be a reflection of a rapid decline in the apparent magnitude of galaxies due to dispersal of photons over a rapidly increasing area (dS_2/dz); increased photon dispersal with distance causes galaxies with a lower absolute magnitude to become invisible. Also, the peak in the Fig. (1) empirical data must closely correspond to a peak in dV/dz.

3. CRISIS IN COSMOLOGY

Assuming that the space density of galaxies is close to uniform on a scale $z << 1$, then Fig. (2) makes it clear that the galaxy redshift survey bins plotted in Fig. (1) should provide some sense of the spatial volume rate of change with redshift. We can surmise from the SDSS CCD images that within the order of $z < 0.1$, a significant percentage of the selected bright galaxies that exist in the survey's field of view are actually counted. It seems unlikely that a large percentage, let alone the vast majority (> 99%), go uncounted anywhere within this range of redshift. Assuming an accurate count, the empirical curves in the Fig. (1) graphs, at least out to the peaks at about $z = 0.1$, should come reasonably close to matching a theoretical curve for dV/dz. When we compare the empirical data to the typical textbook theoretical curve in Fig. (7), the mismatch is extreme. Note that the y-axis is a log scale. The rise in the curve for the Big Bang theoretical prediction and the corresponding empirical observable, which are expected to be at least somewhat similar, differ by several orders of magnitude. Moreover, the peaks of the model and data are separated by more than an order of magnitude in redshift space. This enormous discrepancy between theory and observation suggests that the standard model curve is not just incorrect but is radically so. Moreover, the error is so large that a Copernican solution is clearly required to solve this modern scientific crisis (i.e., a fundamental shift in thinking based on what will in hindsight seem a simple and obvious truth about nature, similar to that which occurred in the 17th century).

$$\frac{dV}{dz} = 16\pi \left\{ \frac{\left[(z+1)^{1/2} - 1 \right]^2}{(z+1)^{5/2}} \right\} \left(\frac{c}{H_0} \right)^3 units \tag{1}$$

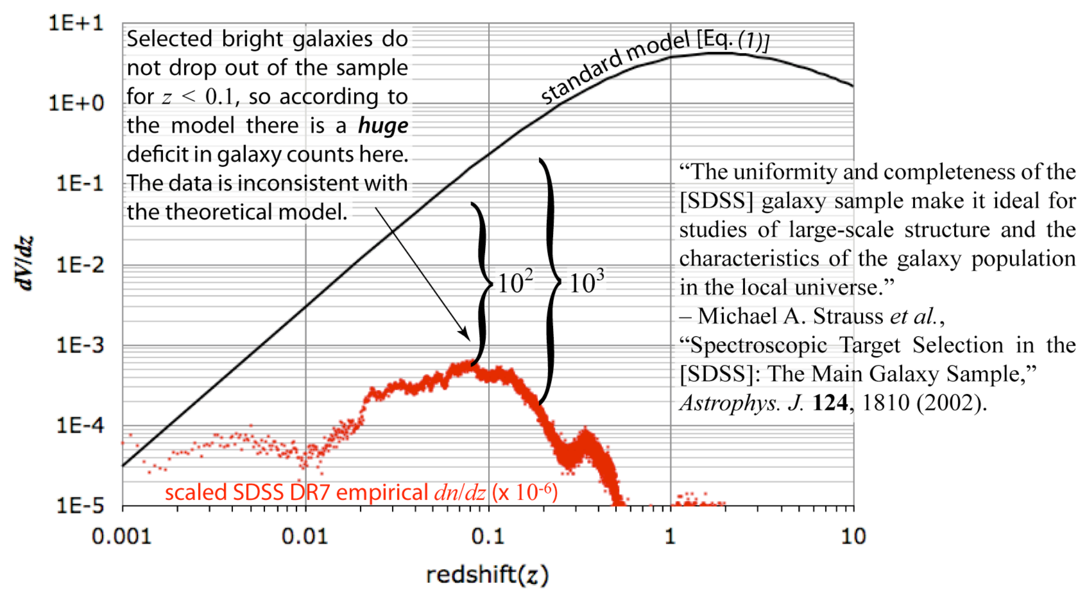


Figure 7 | The canonical dV/dz function vs. empirical dn/dz. The canonical textbook equation for the Einstein-de Sitter model is plotted in black. Conceivable variation of assumed cosmological free parameters including "quintessence" results in no substantial change to the graph's essential features. The SDSS empirical data plotted in red (dn/dz) is displaced for comparison to the theoretical curve and, although not expected to be a perfect fit, it should be a reasonable facsimile of a correct theoretical curve. Integration of the plotted function yields the volume function [$V(z)$]. Comparing the two curves in this context reveals the truly staggering difference between them. The conventional theoretical model is obviously and unequivocally in need of a radical correction. A number of published textbook versions of the conventional cosmological dV/dz function, including considered variations, can be conveniently reviewed online at http://www.sensibleuniverse.com/cosmo/dVdz.html

The misplaced faith in the validity of conventional thinking (i.e., the Big Bang theory) is so strong and prevalent that one can imagine an emotionally motivated denial process to dismiss the very compelling scientific evidence presented in Fig. (7). However, denial is impossible; the empirical evidence is overwhelming due to the unprecedented quantity and quality of cosmologically relevant astrophysical data produced by the two corroborating modern redshift surveys cited.

The apparent angular size of an object is inversely proportional to distance ($\theta \propto d^{-1}$). In astronomy, this "theta-z relationship" correlates the apparent angular diameter of a galaxy (θ) to its redshift. If we make the reasonable assumption that galaxies are structurally similar such that the averaged physical properties of a statistically significant localized group of galaxies is essentially invariant over a broad range of redshift, the Petrosian radius provides a means to obtain empirical "standard rods," which should match the theoretical theta-z relationship.[26] The continuous range in redshift shown in Fig. (8) was chosen for obvious reasons, which include the consistency in the data among the four frequency bands, that the population of the redshift bins of equal depth ($\Delta z = 0.006$) is adequate and reasonably consistent and that the redshifts are cosmological (i.e., uncontaminated by peculiar velocity). Again, the mismatch between conventional theory and observation is extreme, implying a radically incorrect Hubble model.

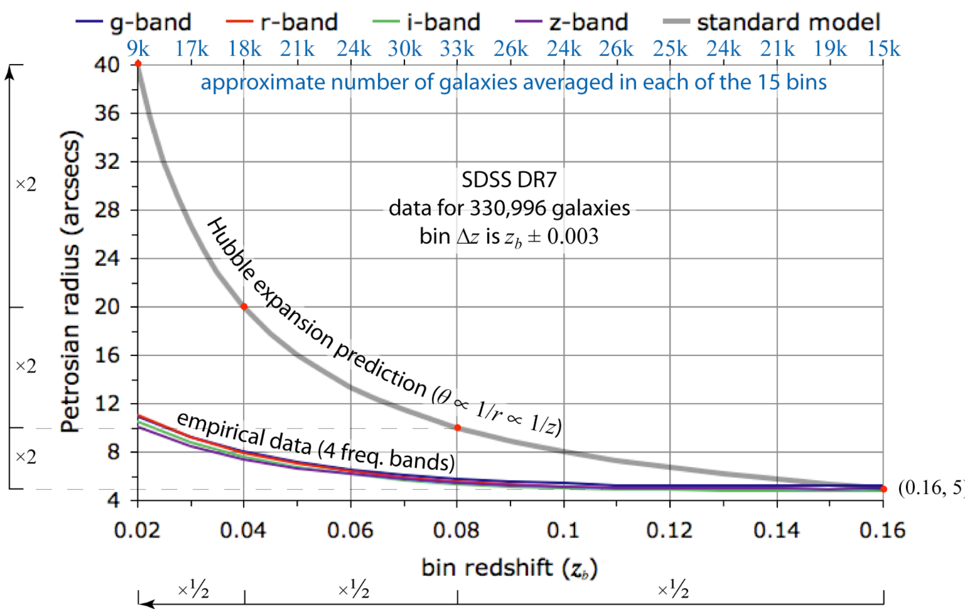


Figure 8 | SDSS empirical theta-z relationship. Data consists of 15 redshift bins averaging the Petrosian radius of thousands of galaxies per bin at z_b intervals of 0.01 for four frequency bands.

http://ExecSQL.info/sdss2.htm

```
SELECT   /* 15 of these queries (s.z bounds vary) produces the data in Fig. (8) & Fig. (9) */
        ROUND( AVG(s.z), 2) AS z
,       ROUND( AVG(petroRad_g), 2) AS g_band
,       ROUND( AVG(petroRad_r), 2) AS r_band
,       ROUND( AVG(petroRad_i), 2) AS i_band
,       ROUND( AVG(petroRad_z), 2) AS z_band
,       COUNT(1) AS n
FROM
        PhotoObj p
,       SpecObj  s
WHERE                               /* 15 different WHERE clauses are used for graphed data */
        s.z > 0.017                 /* also 0.027, 0.037, ... 0.147, 0.157 */
AND     s.z < 0.023                 /* also 0.033, 0.043, ... 0.153, 0.163 */
AND     objType IN (0, 1)           /* galaxies and QSO only */
AND     zStatus IN (3, 4, 6, 7, 9)  /* selected for high quality */
AND     s.SpecObjID = p.SpecObjID;
```

Table (1) provides a historical selection of measurements of the "Hubble constant," including the original alleged "measurement" of 500 by Edwin Hubble in 1929. As compared to measurements of the speed of light, the rest mass of an electron, or the fine structure constant, for which all measurements converge on the same value and resolution has improved over time, it is clear from the historical published data that the "Hubble constant" is not just a misnomer, but a dubious scientific concept at best. With misleading authority, the WMAP science team has published error bars that are at least two orders of magnitude smaller than one can imagine might be justifiable for a "constant" that cannot be measured because it does not really exist. A quote attributed to the great mathematician John von Neumann comes to mind: "There is no sense in being precise when you do not even know what you are talking about."[27]

Table 1 Published measurements of the alleged "Hubble constant" 1929 – 2007

H_0 (km s^{-1} Mpc^{-1})	Principle Author	Method	Year
73.2 +0.031/-0.032	**D. Spergel**	**WMAP (Cosmic Microwave Background)**	**2007**
72 ±6	**X. Wang**	**Type Ia supernovae**	**2006**
68–74 ±10%	**G. Altavilla**	**Type Ia supernovae**	**2004**
48 ±3	**C. Kochanek**	**Gravitational Lens Time Delays**	**2004**
75 +7 / -6	**L. Koopmans**	**Gravitational Lens B1608+656**	**2003**
58 +17 / -15	**V. Cardone**	**Quadruply Imaged Gravitational Lens Systems**	**2003**
81 ±5 & 75 ±8	**N. Tikhonov**	**Distances to Galaxies of the NGC 1023 Group**	**2002**
91	**D. Russell**	**H I Line Width/Linear Diameter Relationship**	**2002**
60 ±10	**Y. Tutui**	**CO-Line Tully-Fisher Relation**	**2001**
72 ±8	**W. Freedman**	**Multiple (HST Key Project to Measure Hubble constant)**	**2001**
46.9 +7.1 / -6.2	**M. Tada**	**Gravitational lens system PG1115+080**	**2000**
50.3 +10.2 / -10.9	**S. Patel**	**Sunyaev-Zel'dovich Effect and X-ray spectroscopy**	**2000**
62	**R. Tripp**	**Supernovae**	**1999**
30 +18 / -7	**C. Lineweaver**	**Cosmic Microwave Background**	**1998**
64 ±13	**T. Kundic**	**Time delay of gravitational lens system 0957+561A,B**	**1997**
50 – 55	**S. Goodwin**	**Galaxy Linear Diameters**	**1997**
70 ±10	**S. Kobayashi**	**Sunyaev-Zel'dovich Effect**	**1996**
67 ±7	**A. Reiss**	**Supernovae**	**1995**
42 ±11	**A. Sandage**	**Luminous spiral galaxies**	**1988**
67 ±4	**N. Visvanathan**	**Virgo cluster distance**	**1985**
55 ±7	**G. Tammann**	**Cepheids, brightest stars, H II regions, luminosity classes**	**1974**
100 ±10	**D. de Vaucouleurs**	**Survey of nearby groups of galaxies**	**1972**
47	**G. Abell**	**Luminosity Function of the Elliptical Galaxies in Virgo**	**1968**
500 (five hundred)	**E. Hubble**	**Cepheids**	**1929**

One must concede that this panoply of radically different measurements in modern times of an alleged "constant," which is the foundation of the Big Bang theory, is troubling. Also, the Big Bang Theory is demonstrably rooted in anachronistic religious tradition and it is naïve to think that this cosmological model did not spring from the biblical cosmogonical paradigm. To interpret the *Book of Genesis* as having anything cogent to say about cosmology, specifically Abbé Georges Lemaître's assumption that a "moment of Creation" has any scientific validity whatsoever, is essentially creationism applied to physics. In addition to alleging a single creation event, the initial paragraph of the *Old Testament* provides chronological details concerning the sequence of the mythic six-day creation. In no uncertain terms, it is specified that the Sun, the Moon and the stars were created *after* the land masses and seas of our planet, as well as its grasses and fruit trees. An assumption of a single primordial cosmic creation event is then closely associated with intellectually primitive ideas involving popular anachronistic myth in contrast to the disciplined scientific practice of extended observational effort and rational analysis.

In *Our Cosmic Habitat* (Princeton U. Press, 2001), Martin Rees, Astronomer Royal of Great Britain and Royal Society Research Professor at Cambridge confessed "99 percent confidence" in the convincing picture of conventional cosmological wisdom that was built up over the last century. Yet, he also stated,

> I would prudently leave the other one percent for the possibility that our satisfaction is as illusory as that of a Ptolemaic astronomer who had successfully fitted some more epicycles. Cosmologists are sometimes chided for being often in error but never in doubt.[28]

Theoretical physicist Richard Price, in the introduction to *The Future of Spacetime* (Norton, 2002), made some insightful comments on this same theme.

> For the centuries of pre-Copernican astronomers there was no question whether the Earth was the center of the world. If difficulties arose, they would look elsewhere for remedies. Those astronomers constructed an extraordinarily complex calculational method to predict and explain the motion of heavenly bodies. An originally simple method of prediction was found to be inadequate when observations of planetary motion improved. Mathematical constructions, "epicycles," were invoked to improve the predictions, and the basic theory was coerced into an appearance of working. This cycle of improvements continued, first in adding astronomical observations, then in adding more unwieldy features to the method.
>
> When we look back at what they were doing, we are incredulous. How could they not see that the simple elegant idea of a Sun-centered world explained everything? They had not so much missed what now seems obvious, as they had been seduced, step by step, down the wrong path. The beginning of the path pointed in a reasonable direction, and from well along the path it was hard to see that there were alternative paths.[29]

Hubble acknowledged that the observed velocity-distance relation could reflect the "de Sitter effect."[30] In 1916, this nascent alternative path interpreted the curvature of space to imply a relativistic time dilation of ideal clocks according to their cosmological distance, but this early interpretation was later abandoned in favor of Lemaître's expanding universe model, which was consistent with the culturally embedded Western paradigm of a sudden supernatural cosmic creation event (i.e., *Genesis*). — In just eight decades (1929–2009), the synergistic achievements of astronomers, astrophysicists, engineers, computer scientists, technicians and enlightened modern scientific thinking have overturned the Big Bang theory, which is really biblical creationism applied to physics rather than to biology. It will be demonstrated that the popularized "expanding universe" model is not just wrong; it is of the same ilk as the spurious Aristotelian cosmology in which all of the astrophysical bodies were allegedly affixed to "crystal spheres" rotating around the Earth, which was imagined to be at rest at the center of the Universe. To presume that the mass-energy of $\sim 10^{80}$ nucleons comprising the entire baryonic mass of the Universe could be compressed into a singular region smaller still than a solitary nucleon and that no cosmic structure has an intrinsic age greater than 13.7 billion years is nothing less than an irrational biblically-inspired distortion of science.

The now mainstream idea in of an expanding Universe rests on the rash assumption that the observed cosmological redshift is indicative of a related recessional motion of the galaxies. One seemingly reasonable assumption led to a series of other invented ideas, each needed to justify the prior, ultimately creating today's belief system of unreasonable *ad hoc* ideas. Each of these ideas invented to "rescue" the Big Bang theory is more unlikely than the last, culminating in "dark energy." In contrast, physicist Howard Burton of the Perimeter Institute in Canada has written,

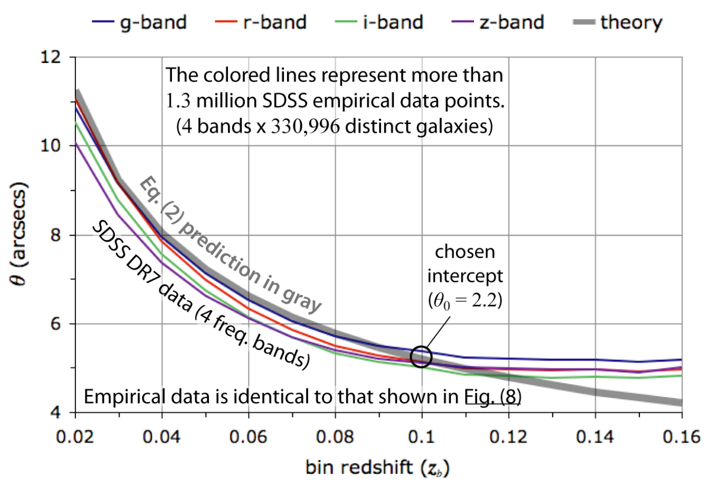
> The pursuit of beauty and elegance has always been a driving force in the development of scientific theories. To its most radical proponents, this bias is based on a firm, axiomatic belief that, at its core, nature simply must be beautiful.[31]

One may add the corollary that nature must be simple, beautifully. In 1908, just prior to his unexpected premature death, Hermann Minkowski established a fundamental geometric foundation for the special theory of relativity and thus a geometric foundation for *time* that is of elemental importance in cosmology. His creative work, which provided some of the most profound physical insights of the 20th century, was misunderstood by Einstein to be a purely formal mathematical development, and is to this day commonly (yet mistakenly) referred to as a mere "mathematical convenience."[32, 33] If one interprets the observed cosmological redshift as indicative of cosmic expansion, logic implies an unphysical singularity in space and time. It is then immediately suspect that this is the wrong interpretation of the observed phenomenon. Properly interpreting the redshift as a relativistic temporal effect that is a function of distance according to the exceedingly simple implications of Minkowski's temporal geometry yields the following two equations (derived in detail later). There are no free parameters; these are precise predictive equations.

$$\theta(z) = \theta_0 \left[\cos^{-1}\left(\frac{1}{(z+1)} \right) \right]^{-1} \text{ arcsec} \tag{2}$$

$$\frac{dV}{dz} = \frac{4\pi}{\sqrt{1-(z+1)^{-2}}} \left(\frac{1}{(z+1)^2} - \frac{1}{(z+1)^4} \right) \tag{3}$$

Having not yet followed its derivation, the first equation here (2) is sure to seem odd to the expert eye. However, when we plot Eq. (2) and compare it to the empirical data with θ_0 = 2.2, which establishes a common point of (0.1, 5.2) for this data set, it is immediately clear that Eq. (2) provides an essentially perfect fit to the observations. The empirical curve flattens out at greater distances for which it is increasingly difficult to measure small galactic radii; statistical averaging of galactic radii at high-z will favor intrinsically larger galaxies. — The latter equation (3) will also be shown to be easily derived in a few steps from first principles and geometry. Its correlation to the empirical data is also startlingly accurate.

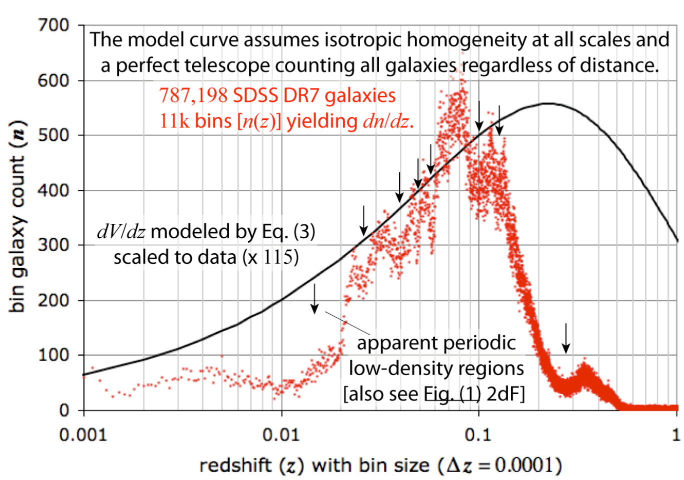


The deviation from the model at higher redshift where the empirical curve flattens out is expected. Statistical averaging will favor larger galaxies that are easier to see, thus artificially increasing the apparent average radius of a higher-redshift galaxy population.

The slope of the empirical curve cannot be artificially suppressed by an abundance of small galaxies at low redshift because there are far fewer galaxies in the 0.02 redshift bin (9k) than in the 0.08 redshift bin (33k).

The 2dF and SDSS redshift survey data is inconsistent with the alleged slope of the SNe redshift-luminosity curve, which implies a 100-fold increase in the volume of the survey bins with a 10-fold increase in redshift.

Figure 9 | Predicted theta-z relationship from Eq. (2) with (z, θ) intercept of (0.1, 5.2).



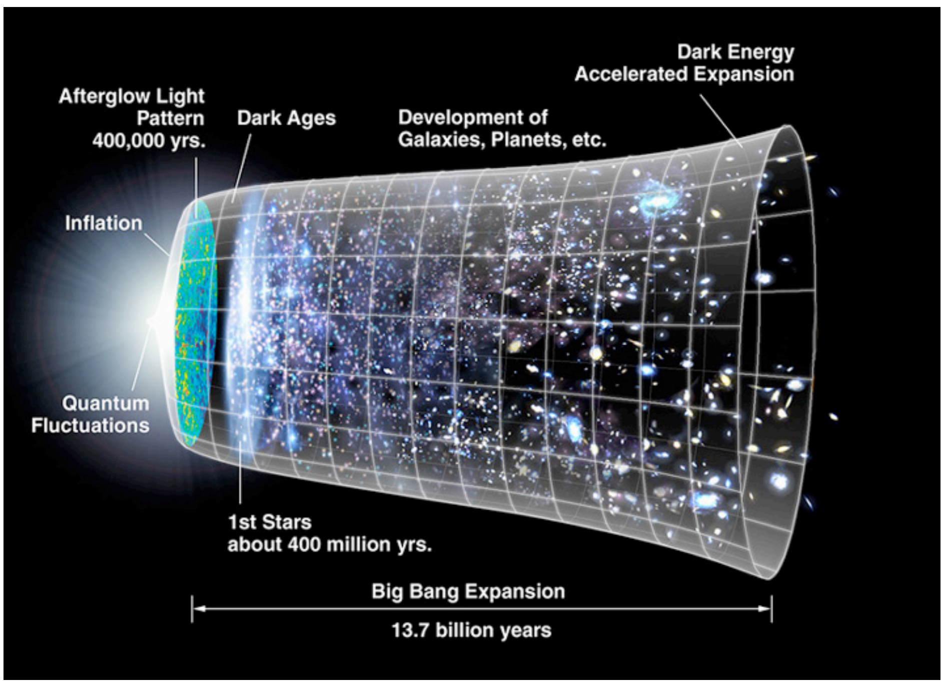
The deviation of the empirical curve from the model curve is expected. One should know that the volume of space between ($0.1 < z < 0.2$) is considerably larger than for ($z < 0.1$). A significantly smaller percentage of the selected galaxies is counted at redshifts above 0.1. This observational effect ensures the displacement of the empirical curve to the left and a sharp decline from the peak. The fractal distribution of galaxies causes the deviation from the model seen at low redshift.

Note that beyond $z = 0.02$, the empirical curve begins to *follow the theoretical curve* immediately following the stair step. This suggests a transitioning from a local fractal architecture to global smoothness, like seeing the Earth from increasing distance. The periodicity of the histogram strongly suggests fractal architecture.

Figure 10 | As compared to Fig. (7), the observations are a good fit to the physical model.
The discrepancies here between the ideal physical model and real-world observations are expected.

4. TIME

A discussion concerning the *physics of time* requires a broad philosophical context as an introduction, particularly in the present epoch during which there is a misunderstanding of time, indeed an insufficient model of relativistic time in physics. — While various individual and cultural differences may exist, it is reasonable to assert that all humans experience time physically and psychologically as relative magnitudes between an irreversible ordered series of events that are measurable to some accuracy by various stable periodic processes. It is also generally true that the human conception of time is formed from the perspective of the present with an overview of acknowledged history. The simple daily calendar is a ubiquitous and ancient measurement device based exclusively on Earth's axial rotation; accordingly, the pervasive practical model of time employed by Western science is the timeline, which typically displays a relevant series of sequential dates or milestones. The majority of people in the world today still do not have a more sophisticated concept of time than that it is related to experiential variation marked primarily by the obvious distinction between day and night. Time is even conceived by many people to be the cause of observed variation in some way, rather than a physical measurement related to some transformational process.



The artistically compelling WMAP Team interpretative model of cosmological history.

Figure 11 | The canonical linear model of universal single-history cosmic time (c. 2009).

Because the curvature of the Earth is so slight (~5.4 minutes of arc over a 10 kilometer distance), ancient man experienced gravity to be unidirectional (parallel everywhere). Given this convincing illusory sensory experience, it was natural to imagine a "flat" Earth and early claims by an errant philosopher-mathematician that the Earth must be spherical according to abstract thought would have contradicted what seemed obvious and intuitively correct according to common experience. Similarly, in modern times, experience throughout life of a uniquely ordered progression of sequential events separated by varying lengths of time readily suggests the model of a single universal timeline (i.e., a 'cosmic calendar').

The idea of relativistic time developed in the context of the preceding paradigm. Although physicists understood that the measured rate of time for distinct reference frames is not constant according to relativity, time in physics continued to be modeled as it is typically experienced: a one-dimensional phenomenon devoid of a meaningful geometry. The much-publicized conventional interpretation of the cosmic microwave background radiation and the simplistic model of cosmic history shown in Fig. (11) is based on a naïve conventional model of cosmological time. The alleged calendar-like history of the

Universe shown in Fig. (11) is modeled by the ubiquitous single linear timeline, the only difference being that no historical continuum exists before the alleged singular *Beginning*. This "edge" of time at the purported Big Bang is of similar naïveté to concepts of a perilous Earth's "edge" found in some fanciful medieval paintings. There is a need for a paradigm shift in the scientific conception of time today that is similar to the shift in the conception of global topology that began in ancient Greece and was effectively complete in the academic world within the first century C.E.[34] The model of the Universe and cosmic time shown in Fig. (11) will soon be regarded to be as simplistic as the ancients' flat model of Earth. Therefore, the new model replacing it requires a reinterpretation of the CMB and its observed anisotropy.

Consider a common object such as a particular apple to which one may associate a unique timeline. The start of the timeline is dependent on the definition of *apple*. For instance, the "genesis event" may be the inexact time when the bud from which the apple grew appeared, an inexact time related to the apple's growth curve, or perhaps the moment in which the apple was separated from its host tree. The genesis event provides a demarcation point in time prior to which the apple, as defined, did not exist. The apple's timeline also has a termination point that is not well defined. It may be the moment in which the apple was cut into pieces, some inexact time during the period in which it was eaten and digested, or some inexact time during the period in which it rotted and could then no longer be distinguished as an apple. Human perception of any physical thing is a representation of a process at a certain point in time that is similar to a photograph (i.e., a snapshot in time); anything physical is made of atoms, which are only temporarily arranged to create it. While it may not be functional to routinely think this way, *object* is not fundamental; all we ever really perceive with our physical senses (i.e., *all* of physical reality) is *process*.

Prior to the advent of special relativity in 1905, time was naïvely imagined to be a cosmic property (i.e., a single parameter relating to the whole Universe). This anachronistic concept of time models the Universe as an object existing in and moving through time so that time is a phenomenon external to the objectified Universe. Albert Einstein's initial revolutionary contributions to the modern concept of time in his epochal manuscript *On the Electrodynamics of Moving Bodies* (translated from the German) include localization of time coordinate, relativity of simultaneity, and relativity of time measurement.[35] In the context of special relativity, time is immediately understood to be an internal construct of the Universe and a property whose measurement is generally restricted to a limited region of space constituting a Lorentzian reference frame. Thus, relativity invalidates the idea of an objectified Universe distinct from time; rather, time is an *internal* local feature of the singular holistic cosmic process.

5. SPACETIME

Hermann Minkowski's concept of spacetime, introduced in 1908, was an epiphany instigated by Einstein's special relativity theory. Minkowski died suddenly and unexpectedly in January 1909 and so never completed the development of his extraordinary ideas, nor was he able to properly communicate them in detail (see *Appendix C*). A querulous young Einstein initially ridiculed Minkowski's vital contribution to relativity as "superfluous erudition," and subsequently never properly understood it.[36]

Minkowski discovered that space and time are distinct transformational manifestations of a unified spacetime fabric. His critical contribution to relativity was to geometrise time. In particular, he recognized that the Lorentz transformation equations of special relativity require the strictly local time coordinate to be imaginary in contrast to the three real-valued space coordinates. Consequently, the foundations of mathematics imply that the time coordinate of a Lorentzian reference frame is fundamentally orthogonal to any chosen space coordinate. The conventional idea that this is merely a "mathematical convenience" is myopic. The mathematics provides fundamental physical insight; in the context of spacetime, the time dimension is physically orthogonal to any space dimension. Perhaps the most important statement in Minkowski's September 1908 address entitled *Space and Time*, which was presented to an assembly of German scientists, has been historically overlooked.

> We should then have in the world, no longer *space*, but an infinite number of spaces analogously as there are in three-dimensional space an infinite number of planes. Three-dimensional geometry becomes a chapter in four-dimensional physics. Now you know why I said at the outset that space and time are to fade away into shadows and only a world in itself [i.e., a *spacetime* Universe] will subsist.[37]

Just as each unique plane in three-dimensional space is associated with a unique orthogonal vector, it should be clear that each unique *space* (x_n, y_n, z_n) of these "infinite number of spaces" in spacetime must have an associated geometrically unique time coordinate (t_n). Therefore, the prevalent idea that "Minkowski space" is composed of three space dimensions (x, y, z) and a single time dimension (t) is a simplistic interpretation of his mathematical insight that completely misses the point. Minkowski's "world" or "4-dimensional space-time continuum" incorporates an infinite number of geometrically and functionally unique time dimensions (t_n), not just one. Paraphrasing the preceding statement from Minkowski's talk, one may state what he made implicitly clear, though not explicitly.

> We should then have in the world (i.e., the spacetime Universe) no longer *time*, but an infinite number of time coordinates (one for each of an infinite number of distinct spaces), analogously as there are in three-dimensional space an infinite number of directions. The geometry of the local timeline becomes a chapter in four-dimensional physics.

The fundamental geometric interpretation of special relativity is that the time dimension is physically orthogonal to any space dimension in a free-falling reference frame; the distinction between what is space and what is time in the four-dimensional spacetime manifold is only locally applicable. This is similar to the strictly local definition of the altitude 'dimension' on the surface of the Earth. Global coordinates (X, Y, Z) associated with an imagined cube circumscribed around the Earth have no physical interpretation. Only the local coordinates (x_p, y_p, z_p), which are valid for the neighborhood of a single point p on the Earth's surface, are uniquely defined *physically*, with the z-axis unambiguously representing *altitude*. There is a similar distinction between the generic abstract "spacetime" dimensions (X^1, X^2, X^3, X^4) and the four measurable "space-time" coordinates of an observer's reference frame (x^0, x^1, x^2, x^3), where x^0 represents local time.

Let a great circle exist in the X^1–X^2 plane of cosmic spacetime [see Fig. (17)]. None of the four generic spacetime dimensions (X^d) has a specific physical interpretation. The orthogonal geometric relationship between space and time that arises from the Lorentz transformation equations implies that there is no universal time dimension (X^0) for an extended interval of space represented by such a curve, which is imagined to circumnavigate the spacetime Universe. Rather, for any local region of space represented by the neighborhood of a distinct point on that curve, local time (x^0) is represented by a local geometric "timeline" orthogonal to the local tangent, (i.e., the local vertical to the curve at any point represents local time there). A symmetric change in the direction of the local time dimension from a point on the curve to another implies a symmetric relativistic temporal relationship between those points (i.e., a bilateral relativistic time dilation). This corollary arising from special relativity's geometric foundation implies the existence of a cosmological redshift-distance relationship for galaxies that is independent of frequency shift related to any relative motion, whether due to a Doppler velocity or a presumed expansion of space between galaxies.

Human thought is generally guided, limited and often confused by preconceived ideas formed in reference to familiar experience. This is why many academics prior to the late 17th century believed that the Sun, the planets and even the stars orbited the Earth and those of ancient civilizations believed that the Earth was flat. — In common human experience, time is measured by some sort of clock, and in one way or another, a clock is observed to record time by counting the cycles of a periodic behavior generally referred to as a "tick." It should be clear that when one commonly observes two timepieces to tick at different rates, one is not experiencing a difference in clock rate, but rather a difference in the unit of time measurement. When relativity has no part to play in order to warrant the discrepancy, one never hears someone correctly report, "The reference time unit counted by my clock is too long." Rather, a commonly heard excuse for tardiness is, "My watch is running slow" (i.e., *falling behind* the correct reference clock). The experiential influence on the perception of time caused physicists of the past to focus their thinking on relative clock rate rather than the relative duration (i.e., relative geometric length in spacetime) of the reference time unit being counted, which produced a deficient 20th-century model of time in physics.

6. TIME DILATION

In his 1905 special relativity paper, Einstein asks the question, "What is the *rate* of this clock when viewed from the stationary system?" In order to achieve greater precision in communicating physics, an equivalent but superior alternative question to pose would have been, "What is the *length* of a second in spacetime [as measured in the 'moving' reference frame] as perceived from the 'stationary' system?"

However, this would not have occurred to Einstein in 1905, particularly as this was several years prior to the discovery of spacetime and the geometrisation of time by Minkowski.

A meter of time as a unit of time measurement is simply the time required for light to travel one meter through vacuum. That time in the context of relativistic physics should be measured in meters rather than seconds is not merely rhetorical; it is the only path toward truly understanding relativity. This is achieved according to what Minkowski called his "mystic formula," in which the speed of light in vacuum represented by the constant of proportionality c is commonly normalized ($c = 1$).

$$x = ict \tag{4}$$

In his famous *Lectures on Physics* at Caltech given some sixty years after Minkowski's epochal lecture, Richard Feynman stated (emphasis added),

> A difference between a space measurement and a time measurement produces a new space measurement. In other words, in the space measurements of one man there is mixed in a little bit of time, as seen by the other.
>
> …
>
> Now in [the Lorentz transformations and the Minkowski metric] *nature is telling us* that time and space are equivalent; *time becomes space*; they should be measured in the same units.[38]

If we understand Minkowski's contribution to imply that time is to be treated mathematically and therefore conceptually in the context of geometry, it then makes perfect sense to interpret temporal effects in special relativity as an equivalent relative change in the length of the reference time unit, rather than the relative rate of clocks. A shift in thinking from the algebra of relative clock rates in one dimension (i.e., the real numbers) to the geometry of relative time lengths in four-dimensional complex spacetime (naturally measured in meters in the context of geometry) allows the inherent symmetries of relativistic measurements to be modeled with unprecedented clarity. The geometric nature of relativistic time revealed by Minkowski implies an infinite number of distinct cosmological timelines, rather than just one, and distinct timelines associated with distinct cosmic regions cannot be parallel.

A puzzling aspect of special relativity is the symmetry of the time dilation phenomenon. As stipulated by the principle of relativity, two observers in unaccelerated relative motion must each find the other's ideal clock to be falling behind an identical local reference clock, which typically presents conceptual difficulties for physics students. If clock B is physically measured to be falling behind clock A, how can it also be that clock A is physically measured to be falling behind clock B? This may seem to be a logical impossibility. Widespread needless confusion concerning this issue arises from improperly thinking about the phenomenon of relativistic time dilation in the context of clock rate (i.e., algebra) rather than the *geometry* of distinct linear time coordinates. It is only with geometry that one can accurately model special relativity with complete clarity, while the algebra originally employed by Lorentz is inadequate.

Like any clock, a typical vehicle odometer measures an interval in one dimension. It is immediately understood that this simple familiar instrument completely ignores the underlying geometry; an odometer indicates how far a car has traveled over a virtual linear coordinate and nothing about the geometry of its motion, which is irrelevant as concerns the primary purpose of the odometer. Consider the following simple illustrative example of relative geometric measurement using familiar vehicle odometers.

Two roads in Kansas (well known for its flat topography) intersect at a 60-degree angle, one headed Northeast, the other Northwest. At the intersection, two experimenters each zero the trip odometers of their respective cars. Subsequently, each drives exactly one kilometer down respective roads separated by the acute angle and each then stops at the side of the road. Accordingly, the odometer in each car reads exactly 1.0 *km*. Clearly, the westbound driver must look over his right shoulder *behind* him to see the other car. Similarly, the eastbound driver must look over her left shoulder behind her to see the other car. Because the cosine of 60 degrees is one-half, relative to the specific direction in which each odometer is measuring distance traveled, the other car is 500 meters behind. Because the drivers are readily aware of the geometry involved in the measurement, it is understood that for each kilometer traveled from the intersection as identically measured by respective accurate odometers, the other car will be perceived to be falling behind by 500 meters. Each kilometer measured by the remote car's odometer corresponds to

only 500 meters of progress in the distinct direction of travel being measured by the local car's odometer. Experientially, each car is simultaneously *falling behind* relative to the progress of the other car, yet there is no paradox because this symmetric "relativity" of measurement is a purely geometric effect.

Although the perception of time in our daily lives is of a universal one-dimensional phenomenon, this is an illusion somewhat similar to the immediate sensory illusion of a 'flat' Earth. The measurement of time by a clock incorporates the relativistic geometry of spacetime, but since every clock in common experience measures time in very nearly the same direction in spacetime, it is natural to imagine that the measurement of time by all clocks involves only one shared dimension of spacetime. If ideal clocks are not synchronous, then our first thought born of experience is that the clocks are measuring time at different *rates* and we stop there, short of a superior model. (The assumption of ideal clocks in theoretical physics implies that every clock faithfully records local time in reference to the same unit of time measurement so that clock discrepancies reflect physical phenomena, not clock inaccuracy.) Yet, if this phenomenon is known to be symmetric, as is true for special relativity, the model of a single timeline and two clocks recording time at different rates introduces a logical inconsistency. No symmetric relative difference in respective time coordinates (i.e., both of two clocks are locally perceived to be gaining time relative to the remote 'moving' clock) can be modeled if the time measurements of both clocks are restricted to the same geometric timeline. Special relativity (SR) forces us to conclude that there are many possible directions of time in spacetime, just as there are many possible directions of Earth's local gravitational gradient in space (that direction being dependent on the local reference frame). A century ago, just before his unfortunate premature death, Hermann Minkowski was trying to communicate the very non-intuitive idea (in his era) that time *in physics* has a multidimensional geometry beyond the perceived single dimension of everyday practical life. Einstein never properly understood this, and therefore neither would those who assumed that Einstein's understanding of relativity was complete and accurate.

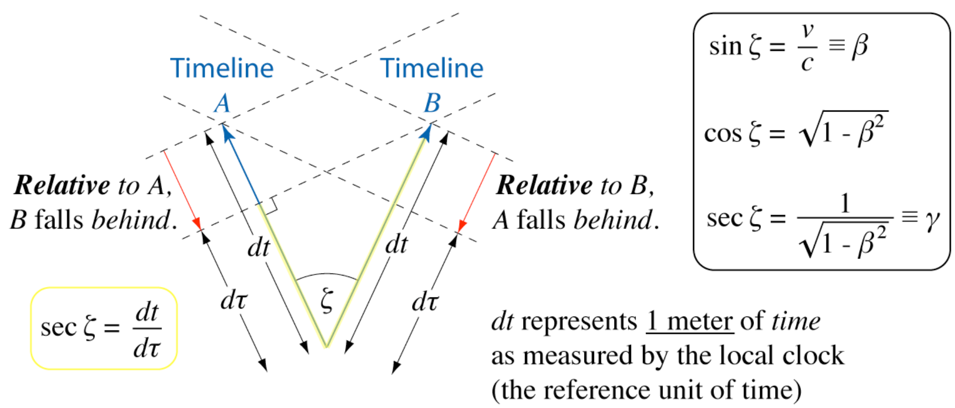


Figure 12 | The geometry of symmetric relativistic time dilation in SR: distinct timelines.
This is strictly a geometric model of relativistic temporal relationships. *Space is not involved*.
The required breakthrough is realizing that this relative projective geometry applies to time in SR.

In Fig. (12), one meter of time as measured in frame B represents less than one meter of time from the perspective of frame A. Consequently, more than one meter of time in frame B corresponds to the local meter of time in A; the length of the equivalent B reference time unit seems "too long." The geometry is perfectly symmetric, so from the perspective of an observer in frame B, all of the same is true in reference to frame A. — When someone complains, "My watch is slow," what they really mean is that the periodic process counted by their watch is producing a reference time unit that is greater than the international standard second. Therefore, relative to an accurate clock, their watch ticks fewer times per standard hour of time, but this asynchrony is due to a mechanical failure. The same principle applies to special relativity in which all clocks are assumed to be ideal and to faithfully record local time with no error whatsoever. Fundamentally, the symmetric retardation of the 'moving' clock relative to the local 'stationary' clock is due to a change in the length of the 'moving' reference time unit, which is a symmetric geometric effect

in spacetime. The measured relative rate of the ‘moving’ clock is a derivative effect caused by the more primary symmetric relative projective geometric relationship between the respective time dimensions of the distinct reference frames. Upon consideration, it is impossible for the general theory of relativity to be a geometric theory of space and time if the special theory of relativity upon which it is based is not also most fundamentally a geometric theory of space and time.

7. THE LORENTZ-FITZGERALD CONTRACTION

Hold a ruler between your thumb and index finger and then extend your arm completely; the ruler takes up its full length of about 30 centimeters in your field of vision. Now slowly rotate the ruler ninety degrees so that it is parallel with your arm. — From your geometric perspective, the ruler appears to contract in length. It is understood that there is no intrinsic change to the ruler whatsoever involved in this apparent contraction; it is strictly a visual geometric effect caused by the ruler rotating from one dimension of space (x) into another distinct (i.e., linearly independent) dimension of space (y).

Recall now Feynman’s succinct and accurate description of relativity, “*time becomes space*.” Going far beyond even Einstein’s imagination, Minkowski discovered spacetime and understood that no fixed physical interpretation could be associated with any of its four dimensions.[39] Relativity implies that we are not entitled to restrict the measurement of time by observers in various distinct reference frames to a single dimension of spacetime. This is reflected by Prof. Kip Thorne’s perspicacious statement describing Einstein’s relativity (paraphrasing Feynman), “*what I call space must be a mixture of your space and your time, and what you call space must be a mixture of my space and my time*.”[40] Therefore, the distinction between a particular time coordinate and its space coordinates in the four-dimensional “world” of spacetime is dependent on the reference frame (i.e., geometric perspective in spacetime) of the observer. Accordingly, herein “space-time” with hyphen refers to a general distinction applied locally in which the abstract generic coordinates of “spacetime” or Minkowski’s “world” are resolved into distinct physical space and time coordinates.

Whereas a rotation in space (e.g., from x into y) causes an apparent visual contraction due to geometric perspective, a rotation in spacetime (e.g., from x into t) causes a real physical contraction that is also due to geometric perspective. In either case, we need only rotate with the object to see that the apparent contraction is a geometric effect, rather than an intrinsic change to the object itself. That is to say, we need to remain in the reference frame of the object such that its coordinates do not rotate relative to our perspective of observation. The Lorentz-Fitzgerald contraction is an effect whereby a component of the length of the ‘moving’ object in question exists in the time dimension of spacetime from the ‘stationary’ observer’s perspective. However, for the observer in the rest frame of the object, that observer’s time dimension is a mixture of space and time measured in the ‘stationary’ frame. If the object were traveling at a constant speed arbitrarily close to the speed of light, then one of its space dimensions would include only an arbitrarily small space component from the perspective of the laboratory. This dimension would instead be almost exclusively associated with the laboratory’s time dimension; “*time becomes space*.”

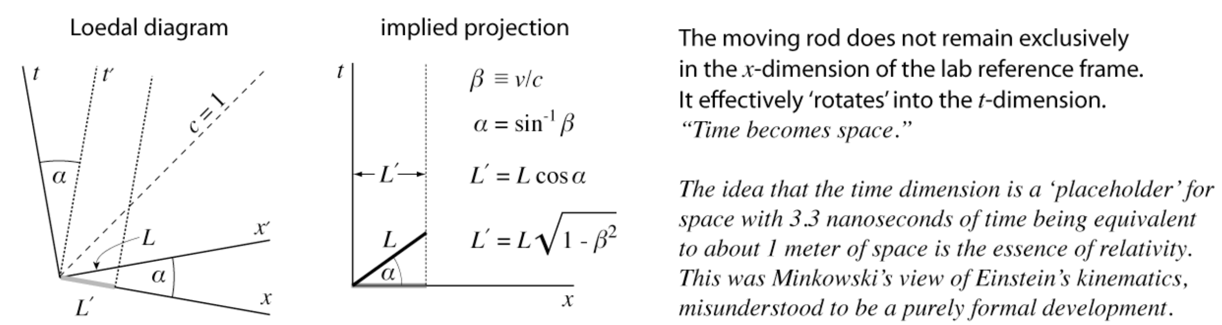


Figure 13 | SR length contraction interpreted as a geometric perspective *in spacetime*.
The principle of relativity implies that the contracted length of the rod (L') as defined by simultaneous events in the laboratory frame is a projection of the full proper length of the rod (L). Logic implies that the rod is projected from a mixture of space and time dimensions because it is not projected from a mixture of space dimensions, as would be the case for a normal rotation in space.

Like ancient people who must have had enormous difficulty conceptualizing the Earth as a sphere (i.e., understanding that the local altitude vector rotates 90 degrees over about a 10,000 *km* distance), for over a century modern physicists have been unable to fully appreciate the geometric implications of special relativity. Although the words were there, fully embracing the real physical meaning was not.

8. THE COSMOLOGICAL BOUNDARY PROBLEM

Philosopher-mathematicians of ancient times who were confronted with the terrestrial boundary problem lived in an era in which the topology of the Earth was not a problem of any practical concern, yet the rhetorical question probably arose as to what would occur if a ship continued to sail in the same direction without deviating from its course. If the Earth was truly flat as then popularly imagined, the ship might continue on forever without encountering a boundary, but only if the imagined terrestrial plane filled with the oceans' waters extended to infinity. However, if this plane were finite in extent, then the ship would eventually have to encounter some kind of physical boundary. The existence of any boundary was logically and philosophically unsatisfactory for a number of obvious reasons. While the first possibility (an infinitely large 'flat' Earth) was conceivable in theory, this idea seemed unlikely to be true. The task at hand was to make observations and measurements to determine the true topology and physical size of the Earth. — Modern astrophysicists and cosmologists have faced the identical problem on a cosmic scale. It should come as no surprise that there is almost no difference between the two problems and their similar solutions. Yet, it *is* surprising that modern scientific professionals have exhibited confusion similar to that of their counterparts in the ancient world, who failed to understand that the Earth is round (i.e., that gravity, which is trivially observed to be locally orthogonal to the surface of the Earth, is not parallel everywhere, which is the key physical concept).

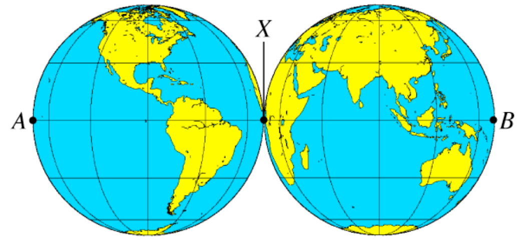


Figure 14 | An orthographic projection of Earth. Points A and B represent the identical location. The distance A–X on the map is obviously πR, whether the path taken is a great arc over the perimeter or the map's linear diameter. Note that the local vertical (i.e., extended radii) at points along the two perimeters can represent either a direction parallel to Earth's surface, as is clearly the case at the arbitrary point X, or a direction perpendicular to the surface (i.e., altitude) at that mapped location.

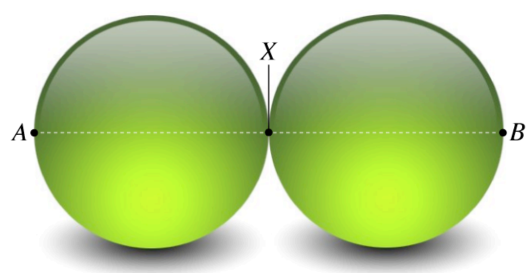


Figure 15 | Two spheres: a 3-D projection of the finite boundaryless spacetime Cosmos. Points A and B represent the identical location. Points A and X (equivalently points B and X) represent cosmological antipodes. The distance A–X on the map is the same, whether the path is represented by any great arc on the surface of either sphere or the linear diameter through the interior of a sphere. Note that the local vertical to any point on the surface of the spheres may represent local time there or may represent the local z-direction of space, as is most evident at the point labeled X.

Ignoring topography, Fig. (14) represents the finite boundaryless 2-D surface of a 2-sphere. — Fig. (15) similarly represents the finite boundaryless volumetric 'surface' of a 3-sphere. It should be clear that just as the respective perimeters of the two circles in Fig. (14) represent the identical set of points, the respective surfaces of the two spheres in Fig. (15) similarly represent the same set of points. — Let us imagine that point X represents the location of our Galaxy. The plane of its disk (i.e., the x-y plane) is tangent to the surface of the spheres, so the axis of rotation (i.e., the z-direction) is along the interior diameter (the dashed line). The point A (and identically B, as it is the same point) represents the cosmic location that is the antipode to the Milky Way. The interior linear diameter A–X represents the same distance as any great arc A–X over the surface of a sphere, just as the linear diameter A–X in Fig. (14) represents the same distance as any great arc A–X.

Einstein's conception of the general theory of relativity (GR) as a geometric theory of the gravitational field is largely based on Minkowski's contribution to special relativity. However, due to his ingenious former mathematics professor's premature death, Einstein never really understood what Minkowski had done in geometrising special relativity; Einstein clearly never understood the geometric nature of time. Because of this, and a fundamental conceptual error that occurred at the beginning of his quest to unify special relativity with accelerated reference frames, Einstein's mathematical approach to general relativity was greatly overcomplicated and so too were the subsequent cosmological models based on the new theory. The fundamental interpretation of general relativity is "excess radius," which is a geometric consequence of the "spacetime curvature" modeled by the Einstein field equations. This "excess radius" exists, but not as it has been conventionally defined in the 1915 version of GR. General relativity incorporates a modeling error with observable empirical consequences, which shall be discussed in a following section.

The physical interpretation of the Minkowski metric involves two essential ideas.

$$ds^2 = -c^2 dt^2 + dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta \, d\phi^2 \tag{5}$$

1) Space and time are *physically* orthogonal dimensions in a locally Lorentzian reference frame,

2) Space and time are *physically* transformational dualities of spacetime (i.e., "*time becomes space*").

Thus, the physical distinctions of local time and of local altitude are geometrically similar.

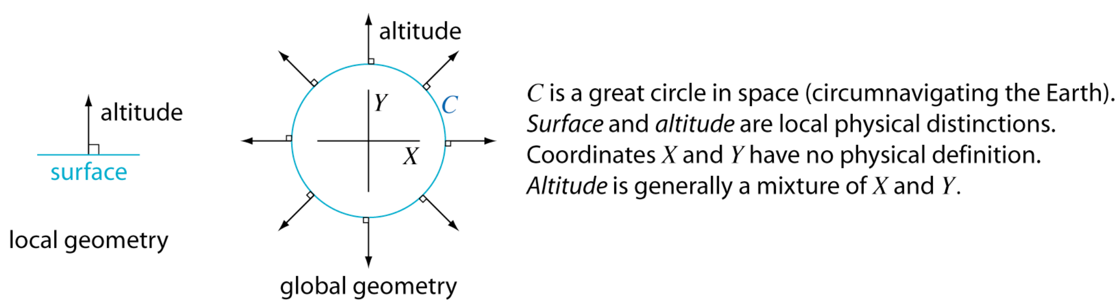


Figure 16 | The familiar distinction between the local and global altitude 'dimension'.

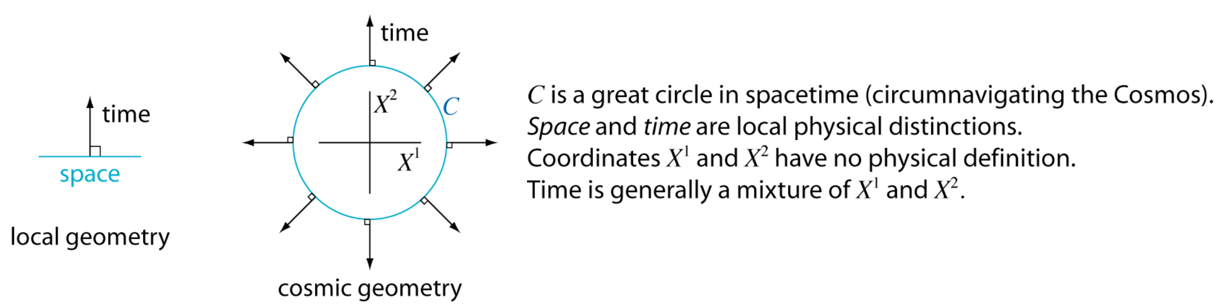


Figure 17 | The cosmic *local time* coordinate is similar to Earth's *local altitude* coordinate.
The strictly local time dimension is generally a mixture of cosmic spacetime coordinates X^1 and X^2.

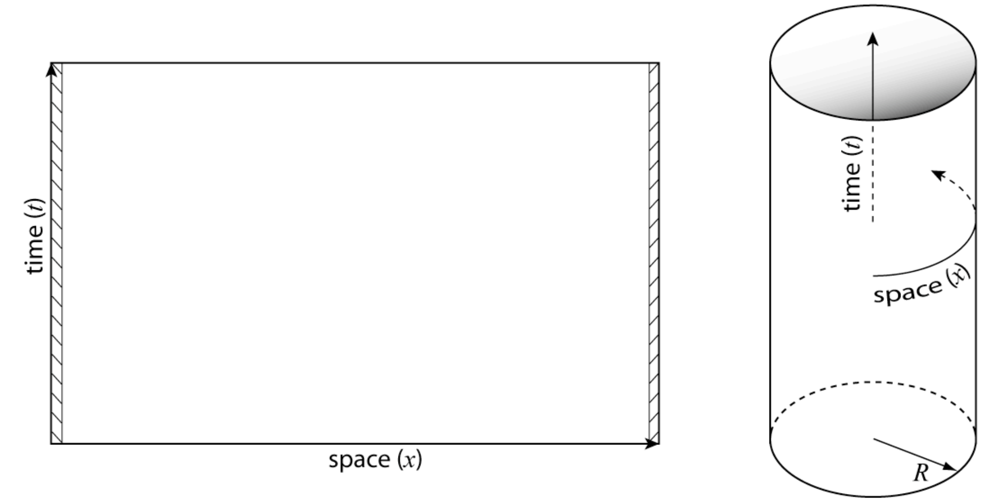


Figure 18 | Cylindrical space-time with one space dimension (x). The two edges of the spacetime plane on the left are connected to form the cylinder on the right. The resulting space has a Euclidean geometry but the topology of a Riemannian hypersphere. Conventional wisdom naïvely assumes that this single time coordinate model is valid for a cosmological great circle with $R = f(t)$.

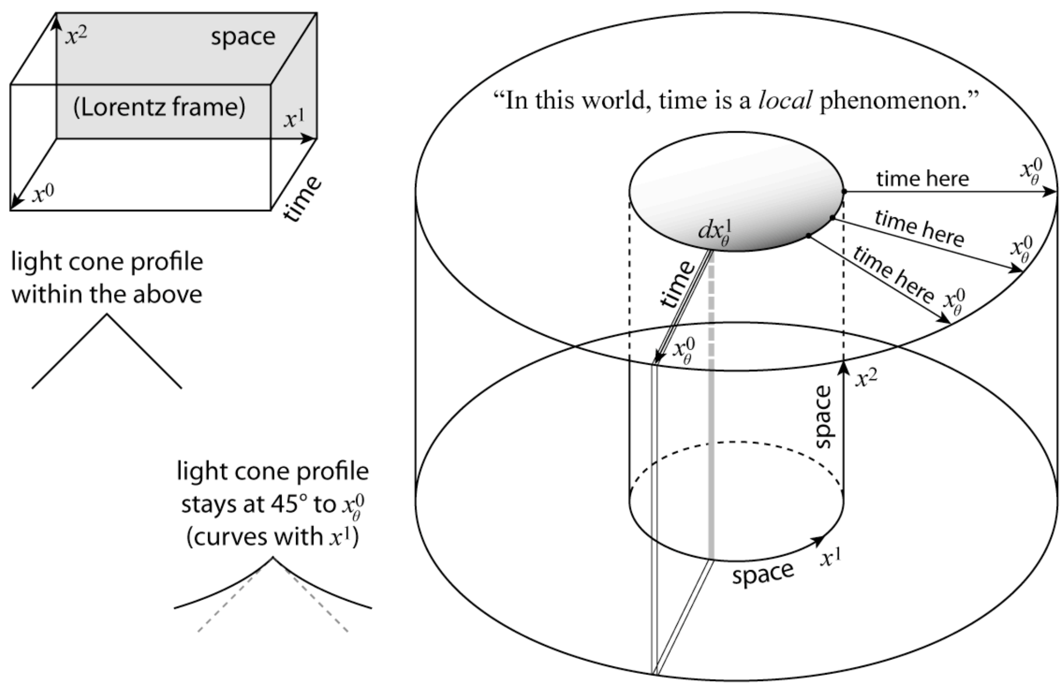


Figure 19 | Cylindrical space-time with two space dimensions. Connecting opposite faces of a rectangular cuboid whose depth represents the time dimension (x^0) provides an intuitive schematic of the resulting non-parallelism of local time coordinates over a connected dimension (here x^1 only). Minkowski's "infinite number of spaces" (review the quote at bottom of page 14) are here abstractly represented by each differential slice ($dx^1{}_\theta$, x^2, $x^0{}_\theta$). Clearly, each of these unique spaces has a geometrically unique time coordinate (i.e., the local radial). If one similarly connects x^2 in order to achieve a natural symmetry, the result is a sphere for which radials represent the unique local time coordinate for the neighbourhood of each unique point (representing a unique "space"). The surface of the sphere represents the total cosmic extent of a local plane in space (e.g., the Galactic disk).

Like the clever Greek philosopher-mathematicians who surmised by logic that the Earth is spherical, perhaps contemplating the fate of a ship that continued to sail in one direction without deviating from its course, today we can imagine a gedanken 'spaceship' conceived to circumnavigate the Universe in a cosmic great circle. The perimeter of the circle in Fig. (17) represents a single closed (i.e., boundaryless) dimension of cosmic space, curved not in space, but in the intangible "world" of Minkowski's spacetime. So, while the one-dimensional perimeter of the circle exclusively represents space, its two-dimensional interior represents *spacetime*. The two coordinates shown (X^1, X^2) do not have a fixed physical interpretation, but rather generally represent a mixture of space and time that depends on the physical location mapped by a point on the circle. Also, in the same way that "negative gravity" does not and cannot exist in Fig. (16), the local experience of proper time in Fig. (17) is identical everywhere.

The key concept that the ancient philosopher-mathematician had to embrace before he could easily understand (with little immediate physical evidence to prove it) that the Earth was spherical was that the direction of gravity (i.e., the local vertical or altitude dimension of space) was not parallel beyond the local approximation. Similarly, the key concept that the modern astrophysicist-cosmologist must embrace before it is easily understood that the Universe is finite yet boundaryless is that the local time dimension in the spacetime Universe is not parallel other than to a close approximation on an immediately local cosmic scale (i.e., a radius of perhaps a few million light years).

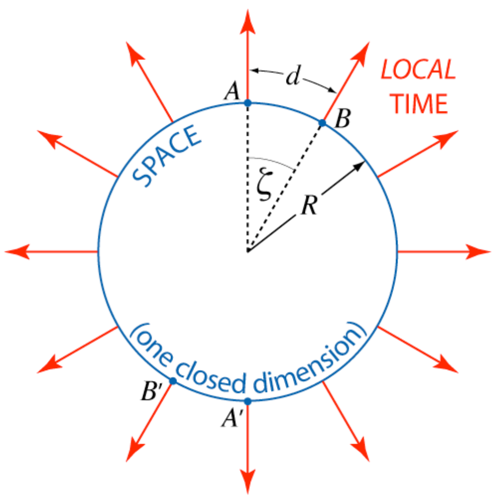
The observable physical implications of the cosmic temporal geometry shown in Fig. (17) are made clear in Fig. (12); a symmetric geometric change in the direction of time in spacetime implies a symmetric relativistic time dilation that is identical to the measurable effects of relative motion. Special relativity tells us and experiment conclusively demonstrates that the perceived rate of an ideal clock in relative motion is less than that of the 'stationary' laboratory clock. With no reference whatsoever to general relativity, the identical theory, when properly interpreted in the context of Minkowski's brilliant mathematical insight, implies that the perceived relative rate of a cosmologically distant ideal clock must be less than a local clock. This readily observable symmetric relativistic temporal effect is completely independent of relative motion. Moreover, the proportional mathematical relationship between the distance to an "ideal clock" (e.g., a light source of known emission frequency) and the corresponding redshift of such a light source due to relativistic time dilation is rigorously defined by pure mathematics (i.e., *geometry*). Additionally, there are no free parameters that can be manipulated to alter the precise prediction of observable relativistic time dilation effects as a function of distance.

9. COSMOLOGICAL LATITUDE

The concept of *cosmological latitude* is now introduced. This is an angular parameter relative to any arbitrary point of observation in the Cosmos. It should be clear that this parameter is unrelated to astrometry, pertaining exclusively to a remote object's distance from an arbitrarily chosen point of observation in the Universe and not to its position in the sky. As is intuitively true for the surface of a sphere, there is no preferred location in space for a finite boundaryless Universe. Therefore, the vantage point from which humans view the observable Universe (i.e., the Milky Way Galaxy) may be arbitrarily selected as the origin of a concentric cosmological map. Its cosmological latitude ζ (*zeta*), which is a coordinate relative to this origin rather than an absolute coordinate, is therefore defined to be zero.

Let point A at 12 o'clock in Fig. (20) represent the location of our galaxy in space and let point B represent the location of some observed distant galaxy whose cosmological redshift may be accurately measured. The circle represents the closed total cosmological extent of what is locally determined to be an arbitrarily defined single dimension of space (e.g., our galaxy's axis of rotation). The cosmological latitude of a distant galaxy at point B is its angular cosmological displacement from the observer up to and inclusive of *pi* radians, which represents the location of the cosmological antipode (e.g., A–A' and B–B'). Note that point A can just as well represent any arbitrary location in the Universe from which an observer looks out to some other distant astrophysical object labeled B. Providing a historical perspective of a time before the idea of an expanding Universe became firmly established within scientific academia, the brief introductory section of a 1935 paper by collaborators Edwin Hubble and Richard Tolman at Caltech in the *Astrophysical Journal* entitled "Two Methods of Investigating the Nature of the Nebular Redshift" is reproduced in its entirety in the following quotation. The emphasis has been added.

> Light arriving from the extra-galactic nebulae exhibits a shift toward the red in the position of its spectral lines, which is approximately proportional to the distance to the emitting nebula. The most obvious explanation of this finding is to regard it as directly correlated with a recessional motion of the nebulae, and this assumption has been commonly adopted in the extensive treatments of nebular motion that have been made with the help of the relativistic theory of gravitation, and also in the more purely kinematical treatment proposed by Milne. Nevertheless, *the possibility that the redshift may be due to some other cause*, connected with the long time or distance involved in the passage of light from nebula to observer, should not be prematurely neglected; and several investigators have indeed suggested such other causes, although without as yet giving an entirely satisfactory detailed account of their mechanism.
>
> Until further evidence is available, both the present writers wish to express an open mind with respect to the ultimate most satisfactory explanation of the nebular red-shift and, in the presentation of purely observational findings, to continue to use the phrase "apparent" velocity of recession. They both incline to the opinion, however, that *if the red-shift is not due to recessional motion*, its explanation will probably involve some quite new physical principles.[41]



While local time points in the opposite direction in spacetime at a relative antipode, the principle of relativity implies that each local timeline is experientially identical to any other. There is no reverse flow of time anywhere that conflicts with causality or the 2nd law of thermodynamics. Observers at A' do not experience time in reverse as compared to those at A any more than 2dF astronomers working "Down Under" live an inverted life as compared to their SDSS counterparts.

In *Section 15*, a correction to general relativity is introduced that predicts previously unexplained observed phenomena. Additionally, the Einstein-Rosen bridge is revitalized. Such a "wormhole" between cosmic antipodal regions (e.g., A–A') allows for continuous dynamic mass-energy redistribution, which provides a means to prevent catastrophic gravitational collapse of the Universe indefinitely without expansion.

Figure 20 | The cosmological latitude *zeta* ($0 \leq \zeta \leq \pi$) measured between cosmic antipodes. Unlike conventional latitude, which is measured relative to an equator between positive and negative antipodes, the cosmological latitude is measured directly between cosmic antipodes. Therefore, ζ is always a positive value ranging between zero (at the arbitrary point of observation) and *pi* radians. The effective spatial radius of the Universe (coefficient R), quantifies the spatial distance between locations ($d = R\zeta$). A distance-related redshift exists between A and B even if R is time-independent.

The foregoing discussion concerning geometric cosmic time provides an alternate explanation for the observed redshift of remote galaxies that is not predicated on the general cosmic expansion model rapidly adopted by Lemaître and Hubble less than a century ago. The majority of scientific professionals are likely to have assumed that interpretations of empirical evidence presented in recent years provide conclusive evidence for an expanding Universe. However, we are no longer entitled to presume this imagined expansion. A fully testable alternative explanation for the observed galactic redshift now presents itself less than a century after the Big Bang hypothesis. According to scientific principles, prior claims by recognized expert academic authorities are irrelevant, and previous alleged "facts" must now be properly treated as assumptions. The quantitative predictions arising from the new relativistic geometric model for the observed galactic redshift must be compared against empirical observations. If these predictions more accurately reflect observations and if the greater theoretical edifice arising from the concept of geometric cosmic time better integrates and explains the totality of empirical evidence without resorting to implausible inventions (e.g., "inflation", "dark energy", "dark matter") then the Big Bang theory must be abandoned. The key result of this discussion is that in ensuing analyses we shall begin by assuming a constant value for the effective radius of the Universe (R) as it appears in Fig. (20). While this

will greatly simplify derivations and calculations, the idea that the size of the Universe is unchanging over time is such an unexpected development in the field of cosmology today that most people would otherwise find it an invalid and even ludicrous leading assumption. This shall not be the case upon comparing quantitative predictions with empirical observations. At that point, it will be clear that performing analyses while assuming ($dR/dt \neq 0$) would be a waste of time.

Eq. (6) is taken directly from Fig. (12); based exclusively on simple geometry, the measured rate of a remote ideal clock ($d\tau$) at cosmological latitude ζ relative to a local clock (dt) is

$$\frac{dt}{d\tau} = \sec\zeta \tag{6}$$

Eq. (7) is the definition of redshift based on frequency where f_0 is the natural emission frequency and f is the observed (typically redshifted) frequency.

$$\frac{f_0}{f} = z + 1 \tag{7}$$

Measurement of photon frequency is fundamentally associated with time measurement. Let a photon have a natural frequency f_0 as measured by an ideal clock #1 (τ) in its emission rest frame. If, from the perspective of a remote observer's local ideal clock #2 (t), a relativistic phenomenon causes this clock to record time faster in comparison to (τ), then according to clock #2, the same number of cycles is counted in a greater amount of time. Accordingly, the apparent emission frequency f of the photon in reference to clock #2 is lower than its natural frequency f_0 (as measured by clock #1) in proportion to the clock rate differential. Consequently, when the photon of natural emitted frequency f_0 according to clock #1 (τ) actually arrives at the remote location of clock #2 (t), it is physically measured by clock #2 to have the lower frequency f according to

$$\frac{f_0}{f} = \frac{dt}{d\tau} \tag{8}$$

Combining equations (7) and (8) yields

$$\frac{dt}{d\tau} = z + 1 \tag{9}$$

Combining equations (6) and (9), observed redshift is expressed in terms of the cosmological latitude.

$$z + 1 = \sec\zeta \tag{10}$$

$$\zeta = \cos^{-1}\left(\frac{1}{z+1}\right) \tag{11}$$

As we do not assume that the cosmological redshift implies a general recession of the galaxies due to cosmic expansion, but rather a relativistic temporal effect associated only with distance, let the effective radius of the spacetime Universe be fixed over all time according to any clock ($dR/dt = 0$) and normalize this cosmic radius ($R = 1$). Then the relationship between cosmological latitude and distance is simply

$$d_{AB} = \zeta_{AB} \tag{12}$$

Combining Eq. (11) and Eq. (12) yields a general equation (13) relating measured cosmological redshift and relative distance, which was previewed in the Eq. (2) theta-z relationship and compared to empirical data in Fig. (9). Skeptics with a conventional mindset must refrain from prejudging this equation prior to understanding that conventional equations from Euclidean geometry for surface area and volume related to distance do not apply. More importantly, the correlation between the predictions of the proposed new model and all relevant empirical observations must be evaluated before passing judgment.

$$d(z) = \cos^{-1}\left(\frac{1}{z+1}\right) \tag{13}$$

Fig. (21) provides a visual model of Eq. (11). It represents half of a complete cosmological map because the adjacent identical second sphere is not shown [see Fig. (15)]. The coordinates shown are relative to the Milky Way's arbitrary location. The primary purpose of this image is to show the relationship between cosmological latitude (ζ) and redshift (z). Like any 2-D map of three-dimensional Earth, this partial 3-D map of the four-dimensional spacetime Universe involves unavoidable distortion. It should be clear that the metric operating on the distorted modeled space cannot be assumed to operate identically on the actual space as is also true for any two-dimensional map of a large region of the Earth. — Fig. (21) may be non-intuitive because our mind has been trained (and is thus inclined) to interpret the geometry we see in terms of what is familiar. This sphere, which is a distorted map, is curved in *spacetime*, not in space, so we must be guided by first principles (i.e., relativity), not our natural inclinations. Per the prior discussion concerning Fig. (15), recall that the spatial distance represented by the internal diameter of the sphere is identical to the spatial distance represented by a great arc on the surface of π radians.

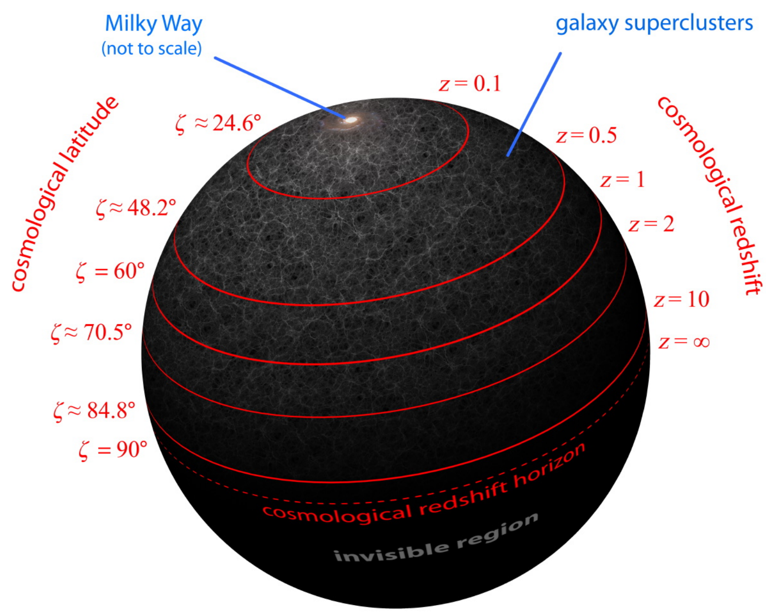


Figure 21 | The relationship between ζ and z in the finite boundaryless Universe. A possible initial reaction to this model is to reject it on the grounds that "we believe that the Universe is flat." This is like rejecting a paper map of the world because we know that the Earth is round. This sphere is a *projection*; the metric operating on the space modeled by the sphere's surface does not correlate to the geometry of the sphere's surface. Note that this is not a model of space but of spacetime, between which there is a broad distinction. The local vertical represents both space and time, just as the local vertical to points on the Fig. (14) circles represents both surface and altitude directions.

The model shown in Fig. (21) incorporates an important insight that is a completely new yet intuitive concept in cosmology. At cosmological latitude $\pi/2$ (i.e., $\zeta = 90º$) the measured redshift of a galaxy at that distance is arbitrarily large; thus, if too great a spatial distance ($d \geq \pi/2$) separates two observers, it is impossible for them to exchange information of any kind. Relative to every observer, there is an effective radial boundary or *cosmological redshift horizon* beyond which the remaining more distant galaxies in the Universe (i.e., those in the cosmic antipodal "hemi-4-sphere") are invisible. Consequently, it is impossible for the closed spatial geometry of the spacetime Universe to produce two diametrically opposed visible images of the same object. There is nothing intrinsically unusual about the cosmological horizon; it is simply a relative cosmological coordinate. — To imagine that local time flows backward beyond this boundary is as childishly naïve as to imagine that people living on the opposite side of the Earth exist "upside

down." (The local vertical to this cosmic sphere represents local proper time.) If the cosmological redshift proves to be a relativistic temporal effect, rather than indicative of expansion, then Fig. (21) is the modern cosmological equivalent of the first terrestrial globe ever constructed by a mapmaker. The first terrestrial globe is alleged to have been made by Crates of Mallus in about 140 B.C.E. That globe, though it may have been lacking in detail, was the first truly accurate physical model of the Earth on the largest scale.

10. THE GEOMETRY OF THE UNIVERSE

The ancients naïvely imagined the Earth to be 'flat' and perhaps limitless. Similarly, people who today have little familiarity with spacetime and the four-dimensional geometry of a Riemannian 3-sphere likely imagine cosmic space to be a kind of limitless celestial sphere (i.e., an infinitely large 2-sphere). While the mapping in Fig. (15) provides an intuitive visualization of finite boundaryless cosmic space, it is also necessary to first define the geometry mathematically and then to quantitatively relate it to astrophysical measurement that can be made with good accuracy (i.e., cosmological redshift). The derivation of Eq. (3), which relates an immediate and accurately measured observable (z) to an indirect observable based on galaxy counts (V), yields a true "precision cosmology." This cosmology has only two free parameters: the effective radius of the Universe (R) and extinction (A) due to the intergalactic medium (IGM). Both of these parameters are subject to accurate estimation based on empirical observations.

Approximating Earth ($\mathbb{S}^3$) to be a unit ball, the geoid surface area is 4π in units of square Earth radii. Taking a similar approach for the $\mathbb{S}^4$ spacetime Universe, the radius of the envisioned cosmic 3-sphere is conveniently normalized (R=1). Accordingly, the line element of a unit 3-sphere is

$$ds^2 = d\psi^2 + \sin^2\psi\left(d\theta^2 + \sin^2\theta\, d\phi^2\right) \tag{14}$$

The total volumetric "surface area" S_3 of a 3-sphere of unit radius is $2\pi^2$ according to

$$S_3 = \int_0^{\pi} d\psi \int_0^{\pi} \sin\psi\ d\theta \int_0^{2\pi} \sin\psi \sin\theta\ d\phi \tag{15}$$

$$S_3 = 4\pi \int_0^{\pi} \sin^2\psi\ d\psi \tag{16}$$

$$S_3 = 2\pi\left(\psi - \cos\psi\sin\psi\right)\Big]_0^{\pi} = 2\pi^2 \tag{17}$$

Referencing Fig. (20) and Fig. (21), it should be clear that the cosmological latitude (ζ) corresponds to the value of the angular parameter ψ in the foregoing geometric equations ($\zeta \equiv \psi$). What is modeled as a great arc through cosmic spacetime ($R{\cdot}\zeta$) is the radial distance measured over the shortest possible distance through space between the telescope and a remote galaxy (i.e., the path of light between the two points). Having conveniently adopted a cosmological unit radius (R = 1), Eq. (18), which is pure geometry, yields a physically meaningful cosmological equation for the volume of enclosed space expressed as a function of the cosmological latitude.

$$S_3 = 2\pi\left(\zeta - \cos\zeta\sin\zeta\right) \tag{18}$$

From Eq. (11) we have equations (19) and (20).

$$\cos\zeta = \frac{1}{(z+1)} \tag{19}$$

$$\sin\zeta = \sqrt{1-\cos^2\zeta} = \left(1 - \frac{1}{(z+1)^2}\right)^{\frac{1}{2}} \tag{20}$$

Substituting for the three terms in Eq. (18) and simplifying yields Eq. (22). Thus, the volume of enclosed space (S_3) is expressed directly as a function of redshift (z). Note that Eq. (22) is an exact formula based exclusively on geometry and first principles and that it involves no free parameters that can be manipulated to alter its fundamental empirical prediction. It is expressed in units of R^3.

$$S_3(z) = 2\pi\left\{\cos^{-1}\left(\frac{1}{z+1}\right) - \left[\left(\frac{1}{z+1}\right)\left(1-\frac{1}{(z+1)^2}\right)^{\frac{1}{2}}\right]\right\} \tag{21}$$

$$S_3(z) = 2\pi\left[\cos^{-1}\left(\frac{1}{z+1}\right) - \left(\frac{1}{(z+1)^2} - \frac{1}{(z+1)^4}\right)^{\frac{1}{2}}\right] \quad R^3 \text{ units} \tag{22}$$

Eq. (22) is graphed in Fig. (22). At arbitrarily large redshift corresponding to a cosmological latitude of 90 degrees, the volume of enclosed space is half of the total volumetric surface area of a 3-sphere (π^2).

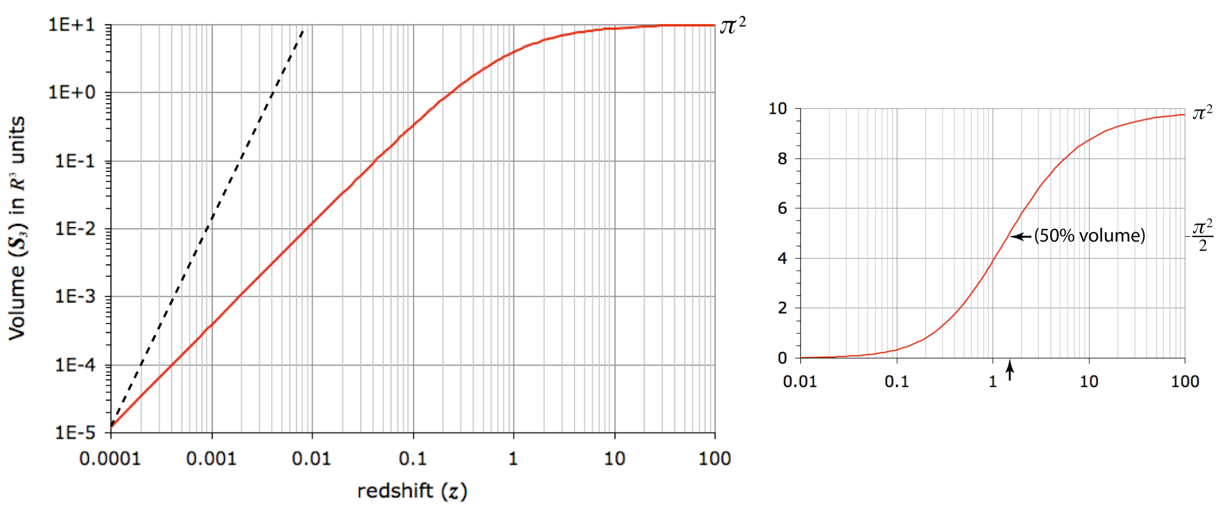


Figure 22 | Graphs of Eq. (22); volume of space as a function of redshift. Ignoring the R^3 units, the dashed black line models the expected relative growth rate of volume at low redshift according to a linear (Hubble) redshift-distance relationship and $V \propto r^3$. A plot with a linear volume scale at right shows that 50% of the space inside the cosmological horizon (the observable cosmic volume) is contained within ($z < 1.5$). About 10% of this total 'observable' volume is beyond $z = 10$.

Differentiating Eq. (22) with respect to z is a somewhat lengthy but straightforward process.

$$u = (z+1)^{-1} \quad \rightarrow \quad S_3(z) = 2\pi\left[\cos^{-1} u - \left(u^2 - u^4\right)^{\frac{1}{2}}\right] \qquad \frac{du}{dz} = -(z+1)^{-2} = -u^2 \tag{23}$$

$$\frac{dS_3}{dz} = 2\pi\left[\frac{-1}{\sqrt{1-u^2}}\frac{du}{dz} - \frac{1}{2\sqrt{u^2-u^4}}\left(2u\frac{du}{dz} - 4u^3\frac{du}{dz}\right)\right] \tag{24}$$

$$\frac{dS_3}{dz} = 2\pi\left[\frac{u^2}{\sqrt{1-u^2}} - \frac{1}{2\sqrt{u^2-u^4}}\left(-2u^3+4u^5\right)\right] = 2\pi\left[\frac{u^2}{\sqrt{1-u^2}} + \frac{u^3}{\sqrt{u^2-u^4}} - \frac{2u^5}{\sqrt{u^2-u^4}}\right] \tag{25}$$

$$\frac{dS_3}{dz} = 2\pi\left[\frac{u^2}{\sqrt{1-u^2}} + \frac{1}{\sqrt{u^2-u^4}}\left(u^3-2u^5\right)\right] = 2\pi\left\{\frac{1}{\sqrt{1-u^2}}\left[u^2+\frac{1}{u}\left(u^3-2u^5\right)\right]\right\} \tag{26}$$

$$\frac{dS_3}{dz} = 4\pi\left[\frac{1}{\sqrt{1-u^2}}\left(u^2-u^4\right)\right] = \frac{4\pi}{\sqrt{1-(z+1)^{-2}}}\left(\frac{1}{(z+1)^2} - \frac{1}{(z+1)^4}\right) \tag{27}$$

Recall that this equation was previewed as Eq. (3) and initially graphed in Fig. (10) for comparison with the scaled SDSS empirical data. In the following larger figure, Eq. (27) is scaled and superimposed on the original graph of the SDSS data out to redshift $z = 1$, which provides more detail of the data.

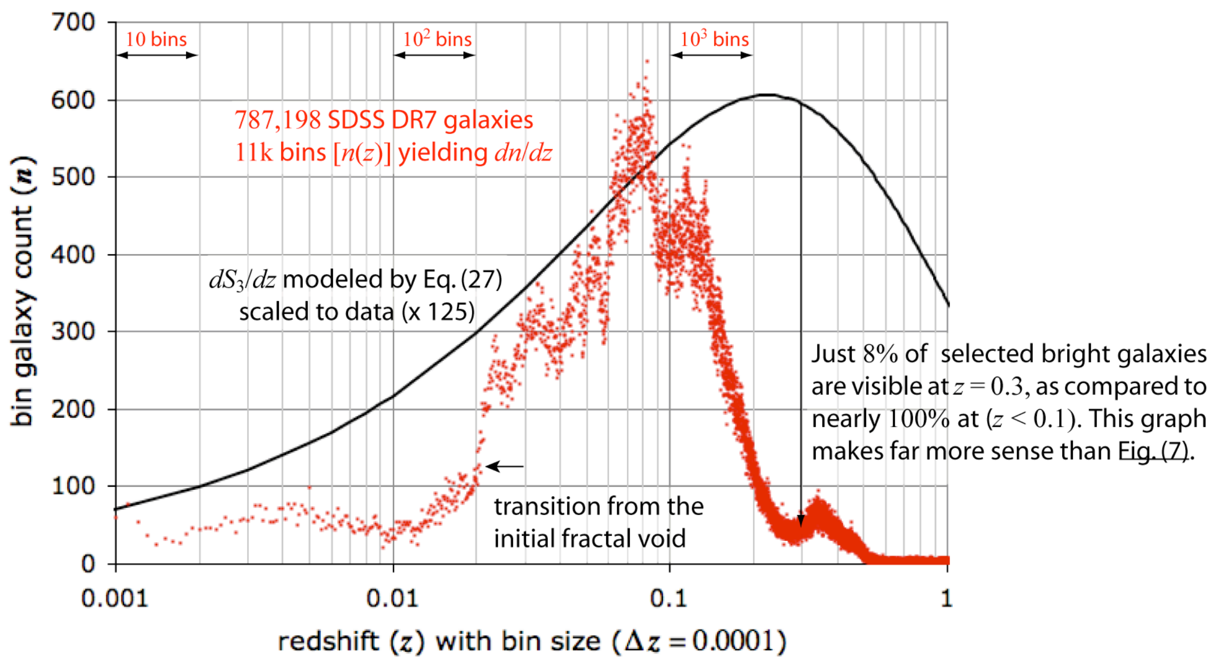


Figure 23 | SDSS DR7 data ($0.001 \le z \le 1$) in red and Eq. (27) in black. Redshift data selected for high quality is sorted into ($\Delta z = 10^{-4}$) bins represented by the dots. $10(10 + 10^2 + 10^3)$ bins are plotted. Variation in bin density due to fractal distribution of galaxies is apparent. The location of the peak of the empirical curve (red) on the z-axis is dependent on the resolution of the telescope used in the survey. It must increasingly shift to the left as the resolving power of the survey telescope declines because more high-z galaxies are missed. Assuming that all galaxies are counted regardless of distance in an ideal homogeneous Universe, the black line is the predicted trend in redshift bin counts. The fractal distribution of galaxies at low redshift, which causes density decline with distance, depresses the empirical curve between ($0.005 \le z \le 0.025$). Few galaxies are found in the local region ($z < 0.001$).

The conventional pseudo-equivalent version of Eq. (22) is Eq. (28), where V is the co-moving volume, defined as the volume in which densities of non-evolving objects (assumed to be) locked into Hubble flow are constant with redshift. It was thought that differential number counts probed the co-moving volume as a function of redshift. — Eq. (28) is the function derived for a homogeneous, isotropic Universe with constant curvature and zero cosmological constant (the Einstein–de Sitter model). The derivative of Eq. (28) with respect to z is Eq. (1), which is plotted as the black line in Fig. (7) and Fig. (24).

$$V(z) = \frac{32}{3}\pi\left(1-\frac{1}{\sqrt{z+1}}\right)^3 \left(\frac{c}{H_0}\right)^3 \text{ units} \tag{28}$$

Although galaxies get harder to see at high redshift, SDSS still counts some fraction of the selected population beyond redshift $z = 1$. An important question to ask is what fraction? According to Eq. (28), the spatial volume bounded by $(1 \le z < 2)$ is double that within a redshift of one, so this textbook equation suggests that an ideal telescope would count twice as many galaxies in this farther region than for $z < 1$.

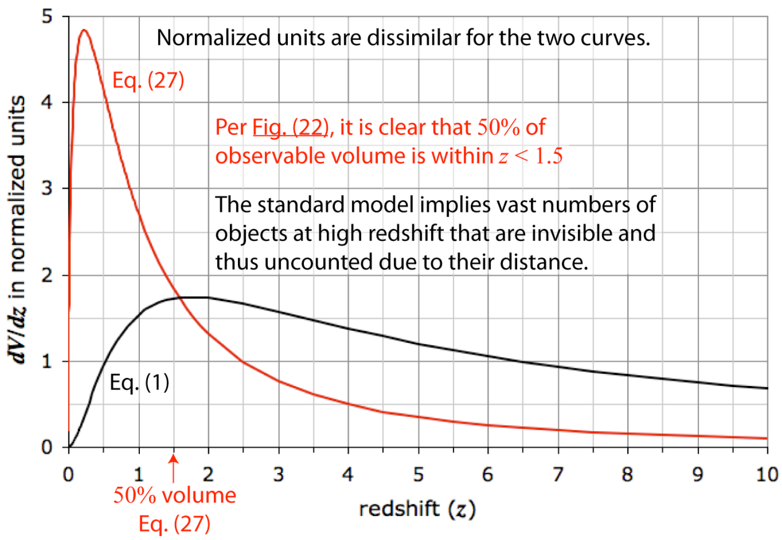


Figure 24 | Graph of Eq. (27) and Eq. (1) showing the volume as a bounded area. The area under the Eq. (27) curve in red models a *physical* volume, while that for the Eq. (1) curve in black models *co-moving* volume. For the red curve, it can be seen that a redshift of $z = 1.5$ corresponds to half the total volume, which is about 20 of the small squares corresponding to about 5 unit squares or $(\pi^2/2)$.

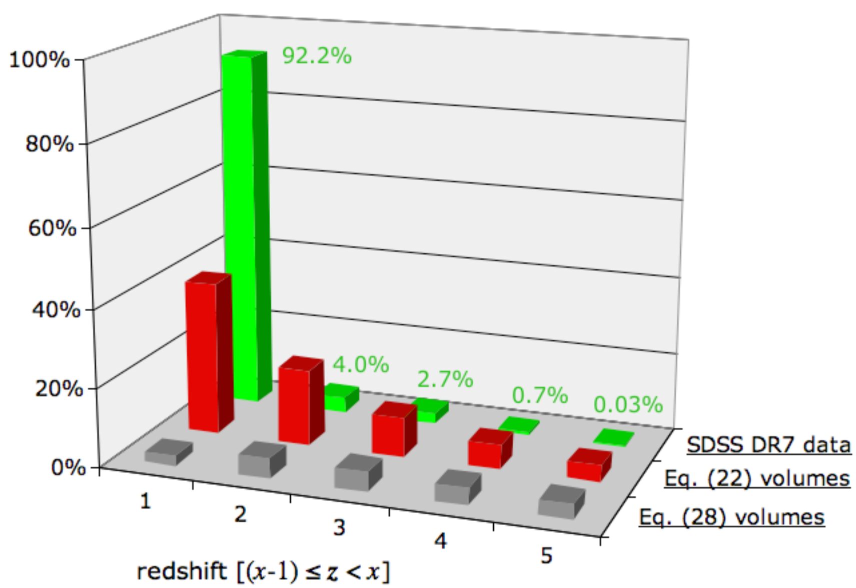


Figure 25 | SDSS DR7 redshift survey data sorted into bins of integer redshift. Observations (in green) clearly follow the modeled volume trend in red. As the second and third green columns are of similar magnitude, the spatial depth of bins 2 and 3 must be much smaller than the depth of bin 1 because galaxies in bin 3 are obviously almost as easy to see as those in bin 2. The volume trend in gray according to the standard cosmological model shows a doubling of volume from bin 1 to bin 2.

The graphed SDSS data in Fig. (25) can be recreated directly from the online SDSS database using the following SQL statement. See http://ExecSQL.info/sdss3.htm

```
SELECT
        ROUND(z, 0) + 1 AS z
,       COUNT(1)/837377.0 AS pct      /* 837377 is the total ungrouped count (z >= 0.001) */
FROM
        SpecObj
WHERE
        objType IN (0, 1)            /* galaxies and QSO only */
AND     zStatus IN (3, 4, 6, 7, 9)   /* selected for high quality */
AND     z >= 0.001                   /* mostly removes misidentified double stars */
GROUP BY
        ROUND(z, 0) + 1
ORDER BY 1;
```

It is important to understand the difference between the red curve and the black curve in Fig. (24) with the corresponding red and gray columns in Fig. (25). The area under the red curve models a real physical volume of space. In this context, the redshift is simply interpreted as a distance; lookback time is irrelevant because the model assumes no change in the volume of the Cosmos over time. The red bars in Fig. (25) imply that if a survey telescope could observe and count distant galaxies just as effectively as nearby galaxies, the empirical green bars would follow the red bars exactly, assuming a large-scale homogenous distribution of galaxies. — In contrast, the co-moving volume interprets lower redshift ($z < 2$) primarily as an increasing distance that implies increasing volume and higher redshift ($z > 2$) as lookback time in an expanding Universe to epochs of a decreasing volume. Thus, the same total volume of space is spread over an increasing amount of lookback time, as represented by the redshift, the farther back in time we initiate lookback. Moreover, as one approaches the mythical spacetime singularity at $T = 0$, and as the total available amount of lookback time approaches zero, the available volume of the Universe also approaches zero. Inflation was an *ad hoc* invention to allow the radius to be greater than cT near $T = 0$.

It is commonly assumed that the intensity of electromagnetic radiation from an isotropic point source is inversely proportional to the square of the distance from the source. This 'inverse square law' arises from the equation for the surface area of a Euclidean sphere. While this law may apply locally, just as Euclidean rather than Riemannian geometry applies to the neighborhood of a point on the surface of a sphere, it obviously cannot apply on the large scale for a finite boundaryless 3-space. In the context of cosmology, photons emitted by an isotropic point source fill S_3, which is modeled by Eq. (22), not the naïve familiar equation for a Euclidean sphere. Being the derivative of S_3, the geometric equation for the surface area S_2 enclosing S_3 is then trivially determined simply by removing the integration from Eq. (16). Recall that ($\zeta \equiv \psi$). This equation provides the physically meaningful result of an increase in S_2 with distance (here expressed in terms of cosmological latitude) only within the specified interval.

$$S_2 = 4\pi \sin^2 \zeta \quad \left[0 \le \zeta \le \frac{\pi}{2} \right] \tag{29}$$

Substituting Eq. (20) into the above yields an exact formula for S_2 in terms of redshift.

$$S_2 = 4\pi \left(1 - \frac{1}{(z+1)^2} \right) \quad R^2 \text{ units} \tag{30}$$

It is important to note that Eq. (30) expresses ($0 \le S_2 \le 4\pi$) in terms of the normalized cosmic radius, not the corresponding physical distance from the observer ($d = \pi/2$). Consequently, at high redshift, the area of photon dispersion from an isotropic point source is modeled to be somewhat smaller than that modeled by the inverse square law arising from Euclidean geometry. The conventional practice of interpreting the apparent magnitude of an astronomical standard candle in the context of the inverse square law is obviously naïve for a finite boundaryless Universe. Indeed, it is similar to the naïve ancient practice of extending locally-valid rules of Euclidean geometry to Earth's entire surface. Even over short distances (in comparison to Earth's radius), the locally-applicable geometric approximation fails.

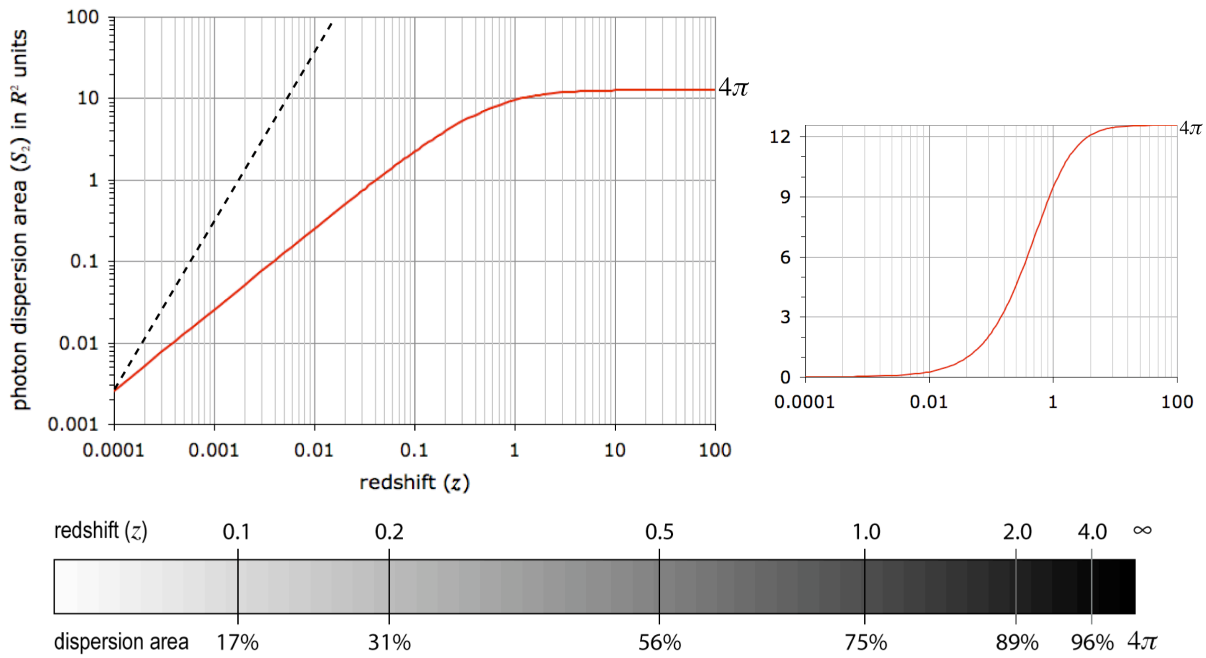


Figure 26 | Graphs of Eq. (30); Photon dispersion area as a function of redshift. Ignoring the R^2 units used for the red curve, the dashed black line models the expected relative growth rate of surface area at low redshift according to a linear (Hubble) redshift-distance relationship and the Euclidean relationship $A \propto r^2$. The geometry of a Euclidean sphere is not applicable to a finite boundaryless spacetime Universe for similar reasons (e.g., the boundary problem) that locally practical plane geometry is not applicable to the spherical surface of the Earth.

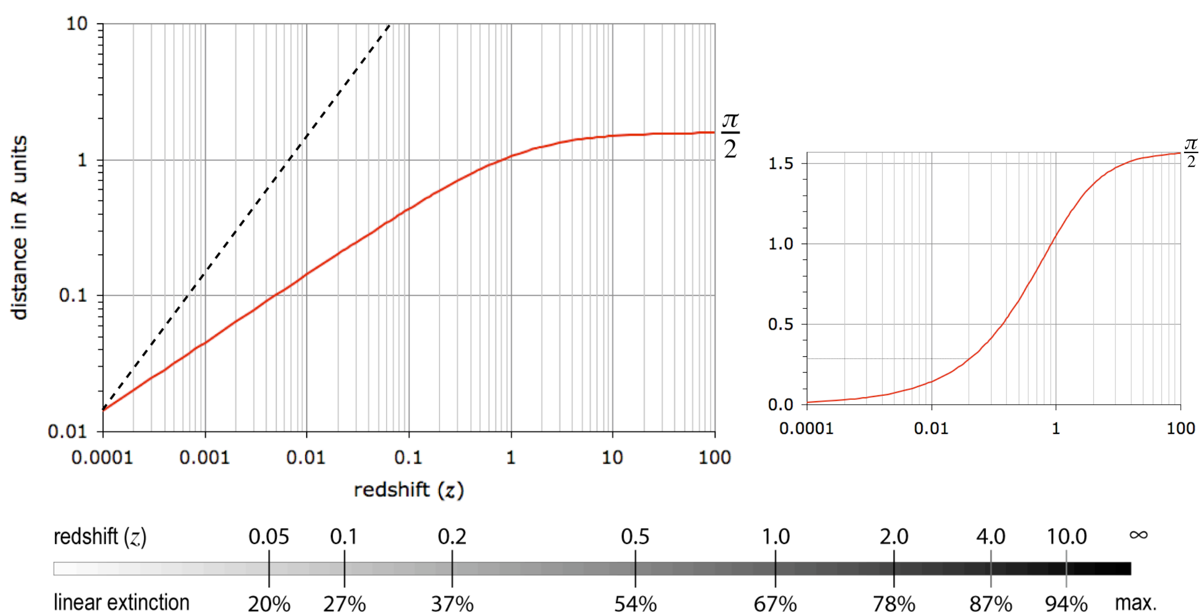


Figure 27 | Graphs of Eq. (13). Ignoring the units used for the red curve, the dashed black line models the linear Hubble redshift-distance relationship. In addition to photon dispersion, intergalactic dust absorbs and scatters photons. It is reasonable to model this effect as linear with respect to distance, however redshifted light from distant sources better penetrates the local IGM dust.

11. THE APPARENT LUMINOSITY OF EXTRA-GALACTIC SUPERNOVAE

Per Eq. (30), the bolometric flux of a standard candle solely due to geometric *dispersion* of photons is

$$F_d(z) = \frac{L}{4\pi\left(1 - \frac{1}{(z+1)^2}\right)} \tag{31}$$

However, the time dilation effect of the cosmological redshift will cause fewer photons to impinge on a CCD per unit time by a factor of $(z+1)^{-1}$ and will additionally reduce their energy by a factor of $(z+1)^{-1}$. This means that the measured bolometric energy flux will be reduced accordingly. To account for this well-known requirement, we must multiply Eq. (31) by $(z+1)^{-2}$.

$$F(z) = \frac{L}{4\pi\left[(z+1)^2 - 1\right]} \tag{32}$$

It is convenient to represent the apparent brightness (F) as a bolometric apparent magnitude. [See Eq. (35).]

$$m(z) = C - 2.512\ \log\left(\frac{L}{4\pi\left[(z+1)^2 - 1\right]}\right) \tag{33}$$

With L normalized to unity, the arbitrary constant C is chosen so that a redshift of $z = 0.01$ corresponds to a magnitude of $m = 14$. Accordingly, a common reference point is established with Fig. (29).

$$m(0.01) = 14 \quad \rightarrow \quad m(z) = 15.50 - 2.512\ \log\left(\frac{1}{4\pi\left[(z+1)^2 - 1\right]}\right) \tag{34}$$

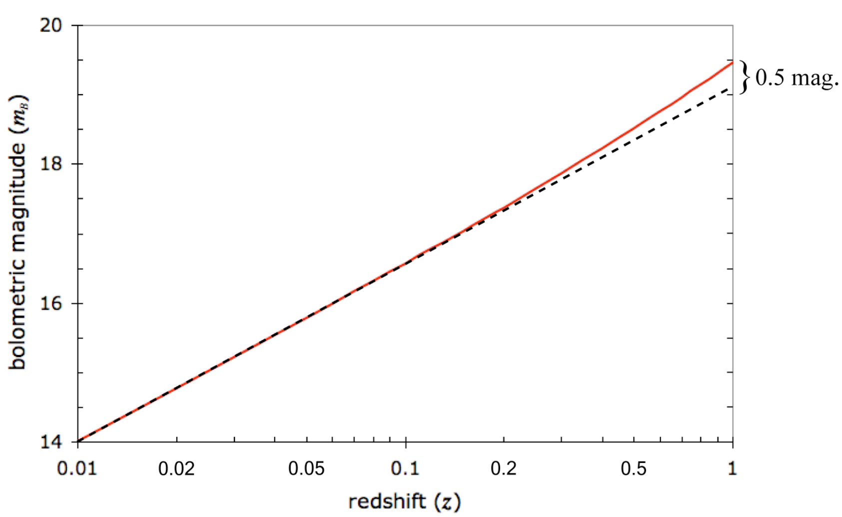


Figure 28 | Graph of Eq. (34). At about $z = 0.2$, the modeled redshift-magnitude curve begins to deviate up from a straight line (in black). This behavior is what led astrophysicists to conclude that the alleged cosmic expansion is accelerating. The alleged transition from deceleration to acceleration is not just unlikely, it is a physical interpretation of the observable that is contrary to the laws of physics (i.e., like Ptolemy's epicycles or an expedient "miracle," it is unequivocally *physically impossible*).

Fig. (7) and Fig. (8) definitively imply that the Big Bang paradigm is incorrect and that its modeling errors are not small. Consequently, the expected redshift-luminosity curve based on the assumption of an expanding Universe, implying a nearly linear redshift-distance relationship, is catastrophically wrong. The empirical data in Fig. (8) can be considered objective and reliable because the data is based on the statistical averaging of more than 1.3 *million* data points (four frequency bands for each galaxy). Moreover, the observation and recording of the redshift and Petrosian radius of SDSS galaxies was not influenced by a perceived need to match an existing (Big Bang) theoretical model, as has been typically required for astronomical research work's acceptance for publication in a peer-reviewed journal.

Conventional textbook cosmology employs an inverse square law and assumes that a decade increase in redshift (e.g., 0.01 to 0.1) corresponds to a decade increase in distance, so the well-known expected decrease in the luminosity (b) of a standard candle over this same range of redshift is one hundred (100), or about five (5) magnitudes on the astronomical luminosity scale according to Pogson's formula.

$$m = C - 2.512\log(b) \qquad \left[2.512 = 100^{1/5}\right] \tag{35}$$

In his famous book, *The Structure of Scientific Revolutions*, Thomas Kuhn wrote,

> That scientists do not usually ask or debate what makes a particular problem or solution legitimate tempts us to suppose that, at least intuitively, they know the answer. But it may only indicate that neither the question nor the answer is felt to be relevant to their research. *Paradigms may be prior to, more binding, and more complete than any set of rules for research that could be unequivocally abstracted from them*.[42] (emphasis added)

The alleged empirical curve in Fig. (29) is an example of how scientific research is similar to all other human activities in that it is controlled to an extreme degree by the dominant paradigm. Over two decades of redshift (0.01 to 1.0), the allegedly objective measurements of Type Ia supernovae apparent luminosity decreases linearly by almost exactly the 10 magnitudes (Δm = 24-14) prescribed by the Big Bang paradigm. Note the telling use of the added word "effective" as a caveat in the label of the apparent luminosity axis. It is as if its authors (Perlmutter *et al.*) are saying, "This *average* slope is not what we actually observe, but we observe this *effective* slope increase, given software analysis of telescope CCD data constrained by the Big Bang paradigm and what we are allowed to report in a peer-reviewed scientific journal."

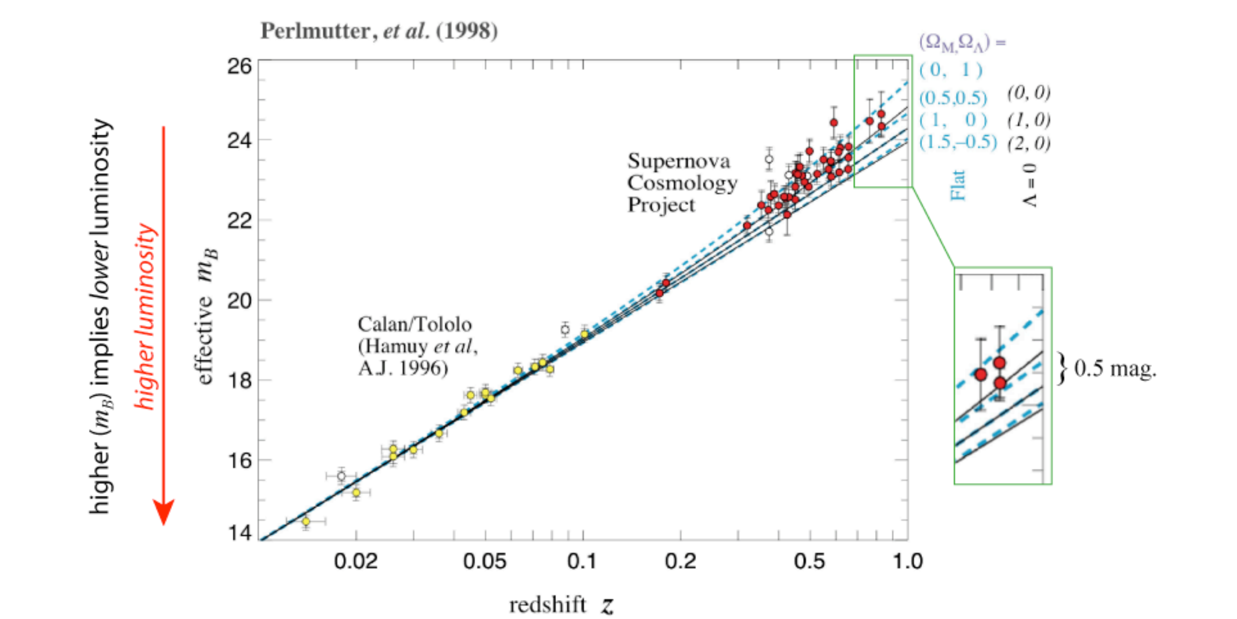


Figure 29 | Published supernovae apparent bolometric magnitude curve.[43] Note the difference of 6 magnitudes in the maximum value of the vertical axis as compared to Fig. (28). The slope of this curve is much steeper than the curve in Fig. (28), which does not yet model extinction.

In Fig. (28) the model produces a decrease in the apparent luminosity of a standard candle (e.g., SN Ia) of about 5.5 magnitudes over redshift (0.01 to 1.0) that is due exclusively to photon dispersion. This is about 4.5 magnitudes (a factor of about 63) short of the expected change (10 magnitudes) according to the standard cosmological model (i.e., the Big Bang paradigm). It is unlikely that extinction due to the IGM dust would cause this 4.5 magnitude discrepancy, but it is reasonable to suppose that extinction may decrease the apparent luminosity of supernovae with increasing distance.

As discussed in Fig. (25), extinction (A) due to an assumed uniform cosmic distribution of IGM dust can be accurately approximated as a linear function of distance. Distance is modeled as an exact function of redshift by Eq. (12), so modeling extinction (light dimming due to absorption and scattering) as a linear function of distance simply requires including a coefficient (ε) in this equation.

$$A = \varepsilon \cos^{-1}\left(\frac{1}{z+1}\right) \tag{36}$$

The SDSS and 2dF data implies that the slope of the Fig. (29) graph is inaccurate, but if we believe this graph then Eq. (34) suggests that it shows an increase of 5 magnitudes from $z = 1$ to $z = 0.01$ due exclusively to extinction. Accordingly, $\varepsilon \approx 5.5$ and $C = 14.73$ in the complete redshift-magnitude equation (37).

$$m(z) = C - 2.512 \log\left(\frac{1}{4\pi\left[(z+1)^2 - 1\right]}\right) + \varepsilon \cos^{-1}\left(\frac{1}{z+1}\right) \tag{37}$$

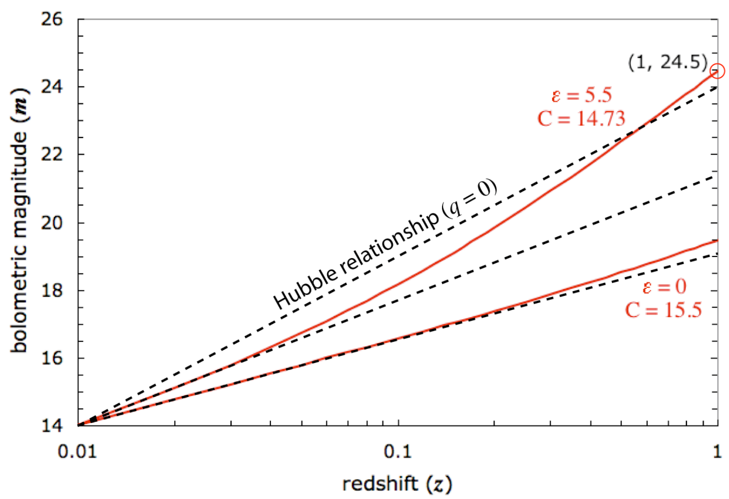


Figure 30 | Graph of Eq. (37). Modeling a large extinction effect in an attempt to match the slope of the Fig. (29) curve causes a significant deviation from the shape of the empirical curve. The *shape* of the reported empirical curve perfectly matches modeled behavior with some extinction, yet its slope is inconsistent with the redshift-distance relationship implied by the SDSS and 2dF surveys.

The corroborating statistical 2dF and SDSS data is inconsistent with the SNe data, so it is virtually certain that the data plotted in Fig. (29) was to a greater or lesser extent adulterated in order to make it conform with the Big Bang paradigm. Ironically, too much of a deviation from this paradigm would have rendered the SNe data unpublishable and would have labeled the research teams who produced it as incompetent. Prior to this book, a substantially different overall slope to the approximately linear curve would have been considered “impossible,” so publishable empirical observations had to be made to fit within socially-allowed boundaries. According to the implications of the galaxy redshift survey data, the question is not whether the data plotted in Fig. (29) is empirically accurate, but the extent of the error. It is likely that the shape of the curve is accurate while its slope was model-driven rather than data-driven.

Even assuming that an expanding Universe makes any physical sense, first principles of modern physics imply that a sudden transition from a decelerating expansion induced by gravity to an accelerating expansion is a physically impossible fantasy. This kind of thinking is indistinguishable from the invention of epicycles as an interpretation of the observed retrograde motion of the planets. The apparent increase in the slope of the SNe redshift-luminosity curve is therefore indicative of a scientific crisis. The principles of modern science (though not those of religion) preclude the arbitrary invention of an inexplicable miraculous phenomenon that is inconsistent with the entire foundation of modern physics. Because a sudden acceleration of the entire Cosmos is *physically impossible* due to the fact that information to induce the imagined fantastic phenomenon can travel no faster than the speed of light, the observation must imply something else. Rather than preternatural "dark energy," Fig. (29) implies human fallibility.

The graph in Fig. (29) was produced for a specific purpose. Initially, prior to the unexpected 1998 "discovery" of an accelerating expansion, astronomers and astrophysicists, who were operating under the controlling influence of the Big Bang paradigm, were expected to accurately measure both the alleged "Hubble constant" and the "*deceleration* parameter" (q). As is made evident in Fig. (28) and Fig. (30), it is no accident or error that they discovered the unexpected slope increase. It is clearly the case that the the two matching sets of empirical data in Fig. (1) and the average slope of the empirical curve in Fig. (29) are inconsistent with one another. In this case of dissimilar information, both cannot be correct. It is obvious which of the three data sets is faulty. The vertical error bars in Fig. (29) are certainly not accurate on an absolute scale; if the SDSS and 2dF data are accurate, then the slope is inaccurate (i.e., the slope of the linear portion of the curve is considerably higher than in physical reality). If extinction effects are indeed significant, there should be even greater deviation of the empirical curve from a straight line.

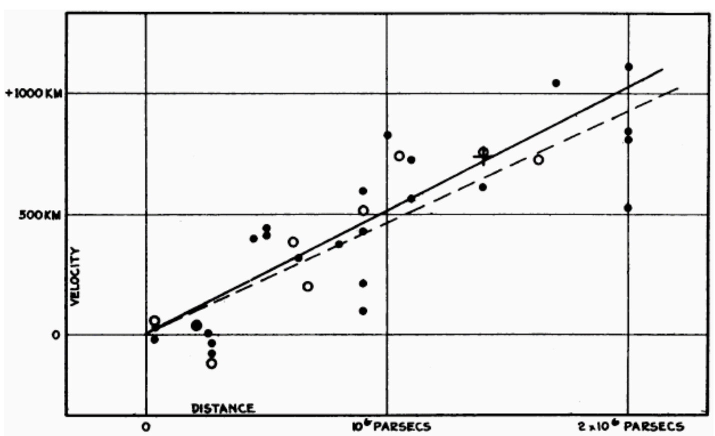


FIGURE 1
Velocity-Distance Relation among Extra-Galactic Nebulae.

Figure 31 | Edwin Hubble's 1929 graph. The title of the 1929 paper appearing in volume 15 of *Proceedings of the National Academy of Sciences*, "A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae," as well as the axis labels and title of "FIGURE 1" shown here provided what seemed to be a definitive interpretation of observations. Hubble's presentation of his observational data as evidence for Lemaître's expanding universe idea, while not a direct lie, was a significant distortion of the facts enabling him to claim a self-aggrandizing major discovery that was superficially consistent with predominant Western religious beliefs arising from the biblical *Genesis*.

The "enduring truth" that Edwin Hubble discovered was that there was some fundamentally *unknown* relationship between distance to a galaxy and its redshift. His famous graph of galactic redshifts with a constant slope of 500 *km/s/Mpc* was in effect another one of his typical departures from the truth; his published data was inaccurate and did not justify the linear redshift-distance relationship that he claimed. Because the inverse of H_0 yields the Hubble time, it later became clear that the slope he claimed for this relationship was too steep by about an order of magnitude, or else the purported "expanding universe" would have to be younger than the already well-established minimum geologic age of the Earth.

History repeats itself. — If the redshift-distance relationship data plotted in Fig. (29) is accurate, then at an arbitrary point in cosmic history, the decelerating effect of gravity suddenly and inexplicably transmuted into a repulsive accelerating potential. Additionally, this would mean that the massive number of corroborating unbiased observations that comprise the 2dF and SDSS galaxy redshift surveys are misleading, while the slope of the supernovae data that is inconsistent with this data is not. Moreover, the Universe is orders of magnitude younger than is evidently required to build the structures it contains. — Fritz Zwicky, an eminent astrophysicist at Caltech who coined the terms "supernova" and "neutron star," made a confident statement in a 1960 paper concerning the age of the largest structures in the Universe.

> The age of 10^{18} years for rich compact clusters of galaxies may be shortened somewhat by considering certain interactions between galaxies that lead to more inelastic and resonant encounters between galaxies. Unless, however, far greater efficiency for the transfer of energy and momentum is postulated for such interactions than is compatible with our present-day knowledge of physical phenomena, the age of rich spherically symmetrical and compact clusters of galaxies is clearly greater than 10^{15} years.[44]

Prior to the advent of geologic time, which was largely initiated by James Hutton (1726–1797), biblically-inspired estimates for the age of the Earth that were accepted as fact by most academics in elite institutions of higher learning were off by about six orders of magnitude, which is about the same difference between Zwicky's numbers and the current constraint on the age of all astrophysical objects according to the Big Bang paradigm. It is now necessary to concede that 20th-century cosmology is largely based on a loose interpretation of mystical writings by primitive Hebrew tribesmen living in the desert thousands of years ago who had no understanding of biological, geological, or *cosmological* history. The Big Bang theory represents a misstep in the scientific process that requires a major correction. The slope of Hubble's original diagram precluded Earth's existence; so too, the slope of the SNe redshift-distance relationship in Fig. (29), as currently interpreted, precludes the existence of observed galaxy clusters.

12. EVIDENCE OF LARGE-SCALE HOMOGENEITY

In his 1970 article in *Science* entitled "The Case for a Hierarchical Cosmology," written some years before Mandelbrot brought forth the concept of fractals, Gérard de Vaucouleurs posed a critical question.

> In fact, since [the mean density of the Universe] ρ is so evidently not a constant independent of space coordinates in our neighbourhood, how large a volume of space do we need to consider before the average density in this volume may be accepted as a valid estimate of ρ? [45]

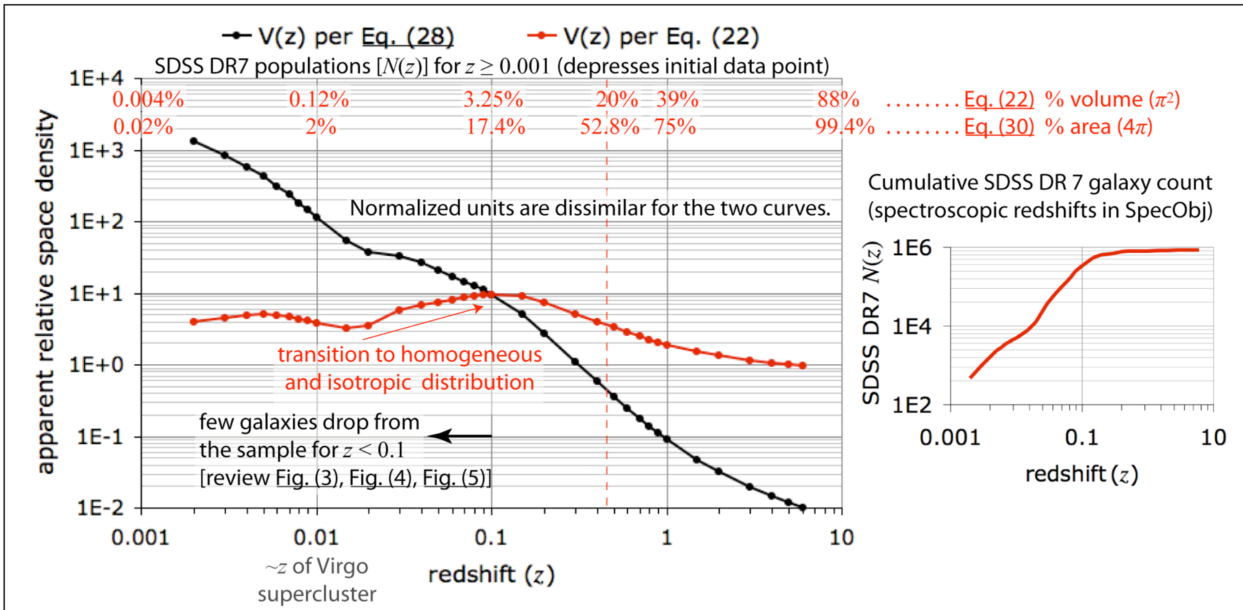


Figure 32 | Relative apparent galaxy space density variation. For each data point (z, ρ), the enclosed survey population is divided by the normalized modeled volume [$\rho = N/V(z)$].

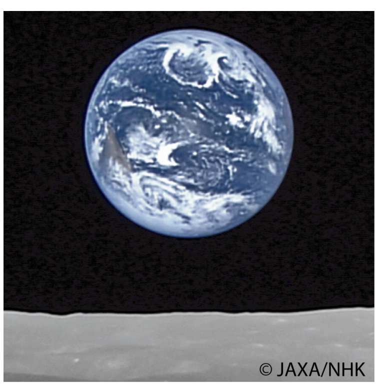
The graphed SDSS data in Fig. (32) can be recreated from the online SDSS data using the following SQL statement, the corresponding numerators from Eq. (28) and Eq. (22) and scaling coefficients (k).

http://ExecSQL.info/sdss4.htm

```
SELECT
       COUNT(1) as N          /* each z queried to yield datapoint (z, N/S3) */
FROM                          /* use scaling coefficients for common point (0.1, 10)
       SpecObj
WHERE
       objType IN (0, 1)             /* galaxies and QSO only */
AND    zStatus IN (3, 4, 6, 7, 9)    /* selected for high quality */
AND    z >= 0.001                    /* mostly removes misidentified double stars */
AND    z <= 0.002;                   /* also 0.003, 0.004, … 0.01, 0.02, 0.03, etc. */
/* perform this query over range of z and divide N by corresponding S3 value from Eq. (22) */
```

Note that the y-axis of the black curve covers 5 orders of magnitude. Based on the Big Bang model, this curve implies that at the distance of the Abell 2255 cluster shown in Fig. (5), either limited resolution has caused a 100-fold decrease in bin counts as compared to z = 0.002, or that the actual galaxy space density has dropped by about 2 orders of magnitude in the range ($0.002 \leq z \leq 0.08$). Clearly, neither one of these options is a real possibility. On the other hand, the red curve, which is based on the new cosmological model, shows a nearly constant space density over the complete range of redshift, which is consistent with the necessity of a homogenous isotropic distribution of galaxies on the large scale. Referencing the smaller Fig. (22) graph, z = 0.45 encloses about 20% of the observable cosmic volume. Then, if not a single galaxy were counted beyond this redshift, the modeled apparent relative space density out to arbitrary redshift would decline by a factor of just 5. The actual observed decline is a factor of about 4. The red curve, which is based on geometric cosmic time (i.e., the Universe is not expanding), is a realistic interpretation of the survey and is distinct from the conventional black curve.

Einstein's homogeneous and isotropic Universe must naturally have a constant galaxy space density, graphed as a horizontal line over the complete range of redshift. In a sense, the planet Earth is a microcosm of the entire Universe. Living on its surface, we see chaos in the form of a fractal geometry down to the scale of rock that we can hold in the palm of our hand. One might literally hold a rock out at arms length against the background of a distant mountain range and easily visualize the rock to be another peak in the range. Yet, from a sufficient distance, the Earth (the proverbial "blue marble") appears to have a perfectly smooth surface, which is due to the fact that gravity naturally causes spherical symmetry.



According to the general theory of relativity the metrical character (curvature) of the four-dimensional space-time continuum is defined at every point by the matter at that point and the state of that matter. Therefore, on account of the lack of uniformity in the distribution of matter, the metrical structure of this continuum must necessarily be very complicated. But if we are concerned with the structure only on a large scale, we may represent matter to ourselves as being uniformly distributed over enormous spaces, so that its density of distribution is a variable function which varies extremely slowly. Thus our procedure will somewhat resemble that of the geodesists who, by means of an ellipsoid, approximate to the shape of the earth's surface, which on a small scale is extremely complicated. – Albert Einstein (1916) [36, 37]

The identical geometric principle applies to the Universe as a whole, although it manifests as a four-dimensional spacetime structure mapped by Fig. (15) and Fig. (21). Just as gravity precludes the Earth from having any significant deviation from an isotropic mass distribution, the same applies to the entire Universe; so, just as the Earth is round and smooth on a large scale, the same is true for the spacetime Universe. — The stair step in Fig. (23) at z = 0.02 implies a significant transition there. Fig. (27) implies that at this redshift we are probing out about 18% of the distance to the redshift horizon and Fig. (22) reveals that this distance corresponds to only a very small fraction (~1%) of the theoretically observable volume of space. Answering de Vaucouleurs's question, this is a surprisingly small volume relative to the totality of cosmic space, although a very large volume considering the number of widely separated galaxies it contains.

13. INTRINSICALLY ANCIENT OBJECTS AT HIGH REDSHIFT

A 1994 NASA press release entitled "Hubble [Telescope] Uncovers New Clues to Galaxy Formation" has an introductory section entitled *The Paradox: Grown-up Galaxies in an Infant Universe.*

> Hubble Space Telescope's recent observations identify fully formed elliptical galaxies in a pair of primordial galaxy clusters that have been surveyed by teams lead by Mark Dickinson of the Space Telescope Science Institute and Duccio Macchetto of the European Space Agency and the Space Telescope Science Institute. Although the clusters were first thought to be extremely distant because of independent ground-based observations, the Hubble images provide sharp enough details to confirm what was only suspected previously.
>
> The surprise is that elliptical galaxies appeared remarkably "normal" when the universe was a fraction of its current age, meaning that they must have formed a short time after the Big Bang.
>
> Dickinson, in studying a cluster that existed when the universe was nearly one-third its current age, finds that its red galaxies resemble ordinary elliptical galaxies, the red color coming from a population of older stars.
>
> This has immediate cosmological implications, since the universe must have been old enough to accommodate them. Cosmologies with high values for the rate of expansion of space (called the Hubble constant, which is needed for calculating the age of the universe) leave little time for these galaxies to form and evolve to the maturity we're seeing in the Hubble image, Dickinson emphasizes.
>
> [Macchetto and Giavalisco identified] a whole cluster of primeval galaxies in that region of the sky...
>
> "The very presence of the cluster ... is unexpected and counter to many theories of cluster and galaxy formation," says Macchetto.[46]

The title and text of a different NASA press release appears more prominently on the *HubbleSite* News Release Archive.[47] Andrea Cimatti *et al.* published similar observations in a July 2004 issue of *Nature*. The following is the abstract from their article entitled "Old galaxies in the young Universe."

> More than half of all stars in the local Universe are found in massive spheroidal galaxies, which are characterized by old stellar populations with little or no current star formation. In present models, such galaxies appear rather late in the history of the Universe as the culmination of a hierarchical merging process, in which larger galaxies are assembled through mergers of smaller precursor galaxies. But observations have not yet established how, or even when, the massive spheroidals formed, nor if their seemingly sudden appearance when the Universe was about half its present age (at redshift $z < 1$) results from a real evolutionary effect (such as a peak of mergers) or from the observational difficulty of identifying them at earlier epochs. Here we report the spectroscopic and morphological identification of four old, fully assembled, massive (10^{11} solar masses) spheroidal galaxies at $1.6 < z < 1.9$, the most distant such objects currently known. The existence of such systems when the Universe was only about one-quarter of its present age shows that the build-up of massive early-type galaxies was much faster in the early Universe than has been expected from theoretical simulations.[48]

Professor Hans Jörg Fahr of Universität Bonn in Germany exhibits exceptionally rare vision and courage for a professional academic in the field with the following remarkably accurate insights.

> When galactic objects are seen at redshifts larger than $z=6$ then it means that they must have emitted their light at a phase when the Universe only had a radius of one seventh (i.e., a volume of 1/350!). According to most of the cosmological models, this phase can only be less than one billion years after the Big Bang event. Since these galactic objects for sure should have ages of more than one billion years, they thus cannot be objects of this Big Bang universe, unless present cosmologies are completely wrong. Then the idea may be suggested as a solution that possibly the Universe may not have an age at all, it only runs through cycles of always repeating processes of production and destruction of objects and hierarchical cosmic structures at all scales of time and space. The Universe is something like a self-sustaining system of nonlinearly interacting non-equilibrium subsystems, dissolving themselves at some places and thereby driving action flows which create identical cosmic entities at other places (see Hoyle *et al.*, 1993, Fahr, 1996, 2002).[49]

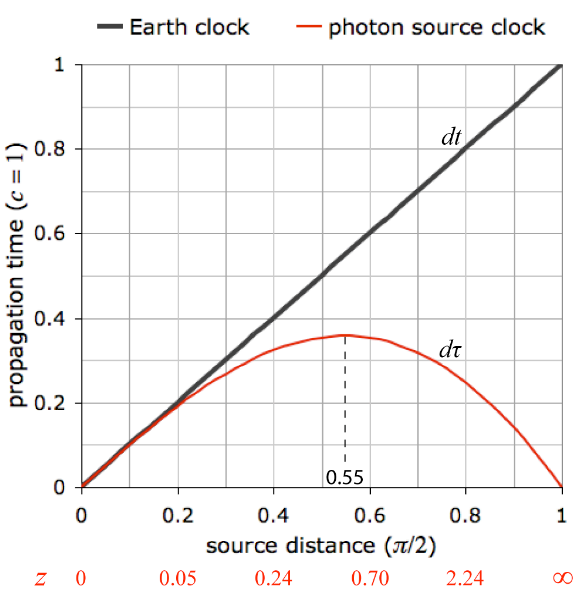
A March 2005 press release by the European Southern Observatory (ESO) describes another corroborating discovery by astronomer Christopher R. Mullis *et al*.[50]

> Combining observations with ESO's Very Large Telescope and ESA's XMM-Newton X-ray observatory, astronomers have discovered the most distant, very massive structure in the Universe known so far.
>
> It is a remote cluster of galaxies that is found to weigh as much as several thousand galaxies like our own Milky Way and is located no less than 9,000 million light-years away.
>
> The VLT images reveal that it contains reddish and elliptical, i.e. old, galaxies. Interestingly, the cluster itself appears to be in a very advanced state of development. It must therefore have formed when the Universe was less than one third of its present age.
>
> The discovery of such a complex and mature structure so early in the history of the Universe is highly surprising. Indeed, until recently it would even have been deemed impossible.[51]

Astronomer Laura Ferrarese made the following comment in a January 2003 issue of *Nature*.

> It has been pointed out that at a redshift of 5 we are [supposed to be] looking back in time to when the age of the Universe (about 1 billion years) was approximately equal to the dynamical timescale of a typical galaxy — roughly speaking, the stellar orbital time, or the time it takes a galaxy to communicate with itself through its own gravitational potential. Thus, the very existence of quasars at such high redshifts is a challenge to models of structure formation.[52]

One of the most fundamental concepts in astronomy and astrophysics is *lookback time*. Depending on its measured redshift, light observed today on Earth arriving from a distant galaxy was emitted at the source hundreds of millions or billions of years ago relative to a terrestrial clock. Due to the finite speed of light, the farther we look out in space with a telescope on Earth, the farther we look back in time as measured by a local ideal clock. The Big Bang paradigm naïvely interprets this lookback time as intrinsic rather than relativistic. The propagation time of a photon as measured relative to an Earth clock allegedly corresponds to the aging of the Universe as a whole, as if the Cosmos were an object existing in time. However, relativity implies that time is a strictly local property *internal* to the Universe, which is a hierarchical collection of spatially and temporally distinct processes identified as objects (e.g., galaxies). Per Eq. (6), the following graph is a simple but profound model of relativistic cosmic time.



The x-axis of this graph is the cosmological latitude (ζ) representing a linear distance. The x-values represent fractions of $\pi/2$. The red curve is a plot of the relationship

$$\frac{dt}{d\tau} = z + 1 = \sec\zeta \quad \rightarrow \quad d\tau = \cos\zeta \; dt$$

According to the Earth clock, the photon flight time is linear with distance (black line); this is conventional "lookback time". The time elapsed on the source clock relative to the Earth clock is a function of the distance to the source (red curve). Thus, the red curve shows the relative rate of aging for distant galaxies as compared to the local Universe.

Figure 33 | Propagation time of a photon. With increasing distance, an ideal clock ticks at an ever decreasing rate relative to an Earth clock. The source ages slower relative to the Earth and the photon propagates in less time according to the remote clock from the perspective of Earth. Strangely, at our cosmological redshift horizon, "time stands still" relative to a reference Earth clock.

The abscissa of Fig. (33), indicating photon source distance, correlates to the map of the finite boundaryless Cosmos shown in Fig. (21). The maximum distance on the scale represents the distance to our cosmological redshift horizon, or one quarter of the cosmic circumference. The ordinate represents time as a distance (*ct*). The black line at 45 degrees represents conventional lookback time according to a terrestrial clock correlated to source distance. The maximum time corresponds to the maximum distance a photon can travel in the Cosmos before all of its energy is dissipated due to the cosmological redshift. This has no bearing on the maximum possible age of an object in the Universe. — The red curve models symmetric cosmic relativistic time dilation. From the perspective of an astronomer on Earth, ideal clocks of increasing distance from the Earth measure proper time at a slower relative rate; light arriving from a distant galaxy takes more time to propagate according to the observatory clock than the perceived 'slow' clock at the photon source. For example, in the case of a galaxy at $z \approx 1.2$ (0.7 on the distance scale), while the Milky Way has aged *n* years from the time the photon was emitted to the time it was observed, the source galaxy has aged only about $3n/7$ years. At the extreme limit of cosmological redshift, proper time is linearly independent from local time. "There is a place where time stands still."[53] An arbitrary large amount of local time may correspond to an arbitrarily small amount of time in the vicinity of the relative cosmological horizon. Moreover, the effect is symmetric; according to an observer at our relative cosmological horizon, it is our clocks that are measuring relativistic cosmic time at an arbitrarily slow rate relative to the local clock. This being the case, it is impossible to associate the property of age to the Universe as a whole, for no universal reference clock exists with which to make such a measurement.

There is no measurable absolute cosmic time and therefore no intrinsic age to any region of the Universe. However, each assembled (hierarchical) physical object, from a single atom synthesized in a supernova to a supercluster of galaxies, is a *process* having an intrinsic *proper age* that can be measured to some degree of accuracy by a local ideal clock. For objects involving strong gravitational fields or significant rotational velocity, the choice of the location of the reference clock clearly affects measurement of the object's age. Recent statements appearing in the literature concerning alleged observations of the "young Universe" are naïve interpretations of lookback time based on the anachronistic Newtonian concept of absolute time, which was incorporated in the cosmic time parameter (*t*) of the Robertson-Walker metric. This metric, which describes the homogenous, isotropic Friedman-Lemaître-Robertson-Walker (FLRW) expanding Universe, fails to recognize Minkowski's legacy of relativistic geometric time. The metric also fails to specify a topology, but rather leaves this as a free parameter. This metric is an example of a canonical mathematical model that incorporates a simplistic anachronistic "God's eye view" of absolute cosmic time.

$$ds^2 = c^2dt^2 - R^2(t)\left[dr^2 + S_k^2(r)\left(d\theta^2 + \sin^2\theta d\phi^2\right)\right] \quad \begin{array}{rcl} S_{+1}(r) & = & \sin(r) \\ S_{-1}(r) & = & \sinh(r) \\ S_0(r) & = & r \end{array} \tag{38}$$

The Big Bang paradigm does not allow any galaxies, let alone bright and fully-formed (i.e., *old*) galaxies to be observed at $z \sim 10$, but relativistic geometric cosmic time allows for galaxies of all kinds to be observed at any redshift and the decrease in apparent luminosity between a standard candle observed at $z = 2$ and at higher observable redshifts is due almost exclusively to time dilation. Observations of high-redshift objects enabled by recent technical innovations suggest that there is no intrinsic age difference between the local Universe and the high-redshift Universe. Astrophysical objects (i.e., processes) of various ages, from the very ancient to the newly emergent, coexist in all regions of the Universe.

> We report the first likely spectroscopic confirmation of a z 10.0 galaxy from our ongoing search for distant galaxies with ISAAC/VLT. Galaxy candidates at z >~ 7 are selected from ultra-deep JHKs images in the core of gravitational lensing clusters for which deep optical imaging is also available, including HST data. The object reported here, found behind Abell 1835, exhibits a faint emission line detected in the J band, leading to z = 10.0 when identified as Ly-a, in excellent agreement with the photometric redshift determination. Redshifts z < 7 are very unlikely for various reasons we discuss. The object is located on the critical lines corresponding to z = 9 to 11.[54]

Objections to claims such as the above, including reliable observation of what are clearly large mature galaxies at very high redshift (e.g, HUDF-JD2) can no longer be based on cosmological arguments.[55, 56]

14. COSMIC MICROWAVE BACKGROUND RADIATION

In the late 1940s and in the 1950s when the Big Bang concept was still considered a tenuous theory, George Gamow and his graduate student collaborators, Ralph Alpher and Robert Herman, made a historic prediction. They posited that if there had indeed been a hot Big Bang followed by an expansion of the Universe, then some heat from the explosion that had cooled with the expansion must remain. In his 1952 book, *The Creation of the Universe*, Gamow predicted that the radiation temperature of the expanded and cooled primeval fireball would be about 50 K. Alpher and Herman had proposed a temperature of 5 K, although they stated that actual temperature measurements would be higher due to the contribution of thermal energy produced by stars in addition to the calculated residual primordial heat.[57,58,59,60]

In 1965, Arno Penzias and Robert Wilson of the Bell Telephone Laboratories made the following observation, which was published in the *Astrophysical Journal*. This is the entire abstract of their paper. Emphasis on the word *possible* has been added.

> Measurements of the effective zenith noise temperature of the 20-foot horn-reflector antenna (Crawford, Hogg, and Hunt 1961) at the Crawford Hill Laboratory, Holmdel, New Jersey, at 4080 Mc/s have yielded a value of about 3.5 K higher than expected. This excess temperature is, within the limits of our observations, isotropic, unpolarized, and free from seasonal variations (July, 1964 - April, 1965). A *possible* explanation for the observed excess noise temperature is the one given by Dicke, Peebles, Roll, and Wilkinson (1965) in a companion letter in this issue.[61]

The following passage is from the paper by the Princeton University team of Dicke, Peebles, Roll and Wilkinson to which Penzias and Wilson referred. It is this famous paper and its four-decade legacy that has given physicists at Princeton a large personal stake in continued support of the Big Bang theory.

> Could the universe have been filled with blackbody radiation from this possible high-temperature state? If so, it is important to notice that as the universe expands the cosmological redshift would serve to adiabatically cool the radiation, while preserving the thermal character. The radiation temperature would vary inversely as the expansion parameter (radius) of the universe…
>
> While all the data are not in hand we propose to present here the possible conclusions to be drawn if we tentatively assume that the measurements of Penzias and Wilson (1965) do indicate blackbody radiation at 3.5º K. We also assume that the universe can be considered to be isotropic and uniform, and that the present energy density in gravitational radiation is a small part of the whole. Wheeler (1958) has remarked that gravitational radiation could be important.
>
> For the purpose of obtaining definite numerical results, we take the present Hubble redshift age to be 10^{10} years.[62]

The coincidence between the discovery of the cosmic microwave background (CMB) and the search for a predicted ubiquitous cooled remnant of a primordial explosion assumed to have started the Universe was not considered to be a coincidence. For all intents and purposes, the discovery was quickly accepted as the definitive proof of the Big Bang; Penzias and Wilson shared the 1978 Nobel Prize in physics for their discovery. What nobody suspected in 1965 was that the cosmological redshift could be readily explained as a relativistic effect based on the geometric relationship between local time coordinates in a finite boundaryless Universe. This being the case, the assumption of a general recession of the galaxies is eradicated at a stroke and with it the fundamental premise for an expanding Universe. There is then no reason to presuppose that the CMB is the cooled heat from a primordial state. The only alternative is that it must be the result of a ubiquitous real-time radiation emission.

The assumption of a Big Bang event a finite time ago leads to the second assumption that photons produced by this source event long ago and far away must exist. However, the isotropy of the background portion of the microwave radiation that is detected leads to the horizon problem. Considering the finite speed of light, how is it possible for causally disconnected regions of the Universe to have the same temperature? Inflation was invented to solve this problem. The inflation theory alleges that the Universe grew by a factor of 10^{50} in ~10^{-32} second at superluminal (>> *c*) speed.[63] This is an *ad hoc* solution to the problem employing an implausible unphysical phenomenon in order to rescue the Big Bang paradigm spawned by the unlikely Lemaître–Hubble interpretation of the redshift circa 1925. In contrast, the concept of geometric cosmic time is fundamental science based on quite simple and irrefutable mathematical and physical principles.

In November 1989, NASA launched the Cosmic Background Explorer (COBE) spacecraft.[64] Its Far infrared (IR) Absolute Spectrophotometer (FIRAS) instrument determined that the CMB has a nearly perfect blackbody spectrum with a temperature of 2.73 *K*. Over a decade later, the Wilkinson Microwave Anisotropy Probe (WMAP), named after science team member Prof. David Wilkinson of Princeton, was launched into orbit on 30 June 2001 from the Kennedy Space Center and inserted into the second Lagrange Point (L2) about 1 million miles beyond Earth on the Solar-Terrestrial radial.[65] Its accomplished mission was to make the first detailed full-sky map of the microwave background radiation with 13' angular resolution, or about 33 times better resolution than COBE. There is no doubt that the making of this map was a significant technical achievement and the team must be applauded for their historic accomplishments. However, they must also be chastened for the content of the WMAP Web site. Instead of exhibiting proper scientific decorum by communicating sober observational facts and humbly suggesting one particular scientific interpretation of them, the Web site seems to literally preach a “revealed truth.” One is confronted with subjectively manipulated observational data and statements implying no room for doubt. It apparently never occurred to anyone on the team that the scientific goal of correctly interpreting the real meaning of the empirical data gathered by the WMAP instruments might remain to be achieved.

From the original WMAP Web site under the ironic title, “Some Theories Win, Some Lose,” we learned about the so-called “winning” theories.[66] The emphasis in the last bullet point has been added.

- Universe is 13.7 billion years old, with a margin of error of close to 1%.
- First stars ignited 200 million years after the Big Bang.
- Light in WMAP picture is from 379,000 years after the Big Bang.
- Content of the Universe:
  - 4% Atoms, 23% Cold Dark Matter, 73% Dark Energy.
  - The data places new constraints on the Dark Energy. It seems more like a “cosmological constant” than a negative-pressure energy field called “quintessence.” But quintessence is not ruled out.
  - Fast moving neutrinos do not play any major role in the evolution of structure in the universe. They would have prevented the early clumping of gas in the universe, delaying the emergence of the first stars, in conflict with the new WMAP data.
- Expansion rate (Hubble constant) value: H_o= 71 (km/sec)/Mpc (with a margin of error of about 5%)
- New evidence for Inflation (in polarized signal)
- For the theory that fits our data, the Universe will expand forever. (*The nature of the dark energy is still a mystery. If it changes with time, or if other unknown and unexpected things happen in the universe, this conclusion could change*.)

The new WMAP Web site includes the following statement from a 7 March 2008 press release.

> Prior to the release of the new five-year data, WMAP already had made a pair of landmark finds. In 2003, the probe’s determination that there is a large percentage of dark energy in the universe erased remaining doubts about dark energy’s very existence. That same year, WMAP also pinpointed the 13.7 billion year age of the universe.[67]

The above pontifical claims supporting the Big Bang theory do not hold up to scientific scrutiny, which can be proven easily by empirical observations guided by a corrected theoretical foundation. If the CMB is produced in real-time, rather than having been sourced in a primordial event, then conservation of energy implies that the production of the CMB is fed by a real-time phenomenon in which microwave radiation is emitted in a ubiquitous process of energy transformation. This process has already been identified through analysis of the WMAP data.

It is often quoted that observation of the cosmic microwave background radiation established the hot Big Bang paradigm beyond reasonable doubt and provided firm observational evidence for an evolving Universe with a well-defined beginning. What this reveals is that the cosmological redshift was not itself considered proof of an expanding Universe beyond reasonable doubt. In other words, the redshift was appropriately considered to be subject to a possible alternative explanation. The common perception that the redshift and the CMB are corroborating independent proofs of the Big Bang is false; the conventional interpretation of the CMB is in fact predicated on the idea of an expanding Universe. Because of this, no

alternative explanation for the CMB has ever really been considered as a possibility, yet the following is a brief cogent quote from an article in the January 2005 issue of *Physics World* referencing work published in the 26 November 2004 *Physical Review Letters*.[68] Its implications seem to have been summarily discounted by the majority of the relevant academic community.

> The cosmic microwave background is often called the echo of the Big Bang, but recent research suggests that some of its features might have their origins much closer to home. Although most cosmologists think that the tiny variations in the temperature of the background are related to quantum fluctuations in the early universe, Glenn Starkman and colleagues at CERN and Case Western Reserve University in the US have now found evidence that some of these variations might have their roots in processes occurring in the solar system. If correct, the new work would require major revisions to the standard model of cosmology. … "Each of these correlations could just be an accident," says Starkman. "But we are piling up accident on accident. Maybe it is not an accident and, in fact, there is some new physics going on."[69]

A hint as to what is going on is found in the following series of WMAP images.

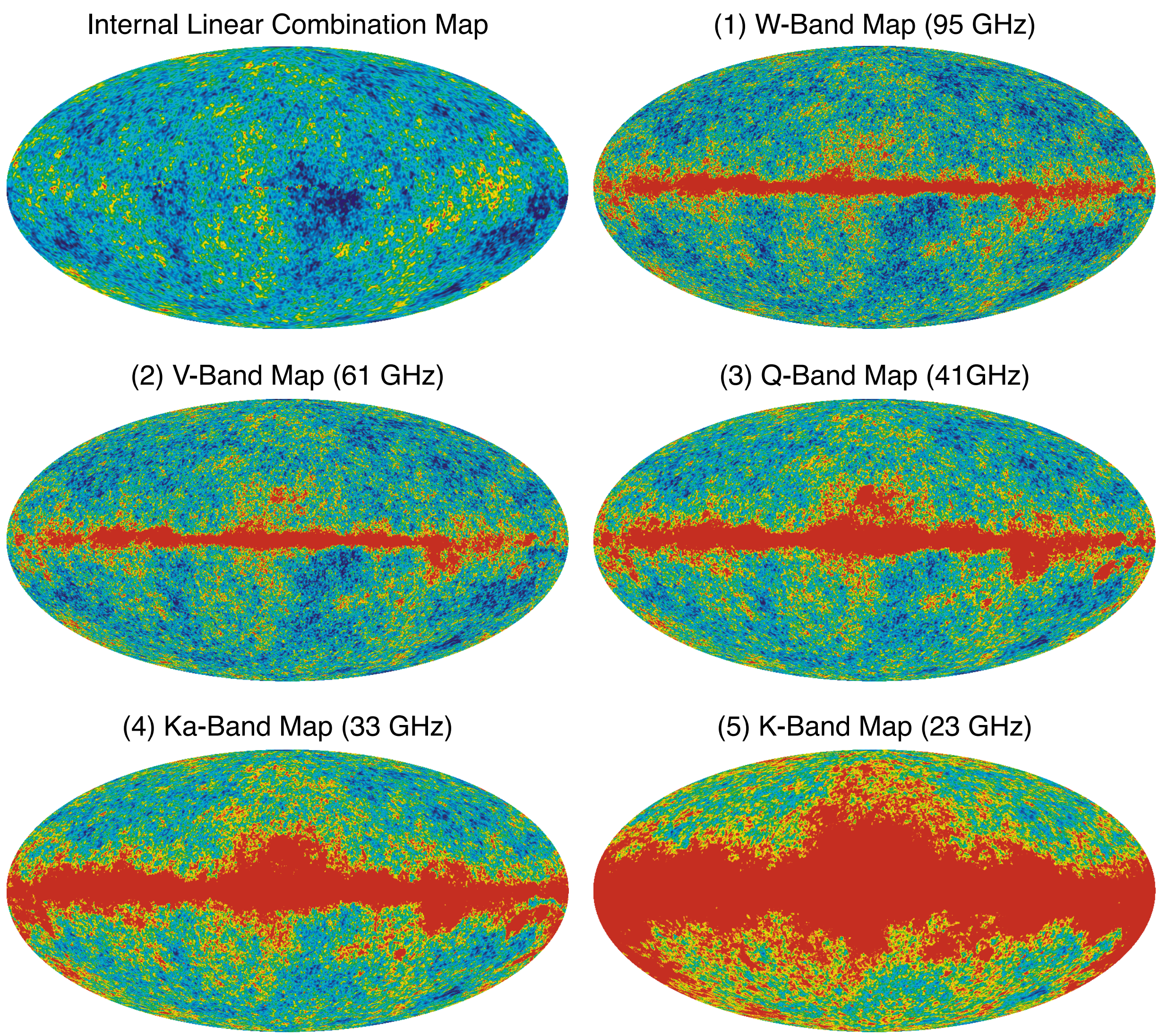


Figure 34 | WMAP full-sky temperature maps (linear scale from -200 to +200 μK).
Courtesy WMAP Science Team.

The touted results of the WMAP mission were summarized for the popular press in a single processed digital image described as follows (emphasis added).

> The Internal Linear Combination Map is a weighted linear combination of the five WMAP frequency maps. The weights are computed using criteria which *minimize the Galactic foreground contribution* to the sky signal. The resultant map provides a low-contamination image of the CMB anisotropy.[70]

In other words, the much publicized map is a convenient fabrication created by removing essential data. The label of "contamination" for empirical data is very likely to be a subjective assessment. Removal of empirical data that inconveniently does not fit the theory one is trying to prove is bad science at best. Each of the five authentic source maps in Fig. (34) is an equal-area Mollweide projection that depicts the entire celestial sphere as an oval with the central meridian corresponding to the plane of the Milky Way. The maps exhibit the same linear temperature scale from -200 to 200 μK ($\pm 2\times10^{-4} K$). The red color represents the "warmer" regions while the blue color represents the "cooler" regions as compared to the median CMB temperature in blue-green. The Galaxy is obviously a significant source of microwave radiation, including excess emission *whose source could not be identified*.

> The cause of observed inner galaxy excess microwave emission is assumed to be synchrotron emission from highly relativistic electron-positron pairs produced by dark matter particle annihilation as more conventional sources have been ruled out.[71, 72]

The above quote is from a paper by Douglas Finkbeiner, a Hubble Fellow at Princeton and an assistant professor at Harvard's Center for Astrophysics. This is a far-reaching assumption and yet another example of modern "epicycles" (i.e., an unphysical *ad hoc* invention attempting to describe observed phenomena). In light of the revelation that the cosmological redshift does not imply an expansion from a primordial explosion, the implications of the empirical observations are clear: *The unknown astrophysical source of the excess Galactic microwave radiation is the same as for the cosmic microwave background radiation*. The distinction drawn between the microwave background, whose source was assumed to be known, and the portions of the microwave foreground openly acknowledged to be of unknown origin is arbitrary. While the nearly isotropic microwave background and the microwave foreground can be distinguished so that the latter can be removed, there is a phenomenological connection between them. Moreover, the microwave foreground is not limited to the obvious Galactic source but also has an apparent Solar System origin that was too subtle to be noted and removed from the initial WMAP data release.

> — astrophysicists have found that the plane of the solar system threads itself through hot and cold spots in the cosmic microwave background, suggesting that some of the variations in the latter are not caused by events that took place in the early universe.[73]

The critical question to ask is, "What does the Solar System have in common with the galaxy?" — Both the Solar System and the galaxy are dynamical gravitational systems involving *rotational motion*. The Sun represents approximately 99.9% of Solar System mass and the solar equatorial plane is inclined about 7 degrees to the Ecliptic plane. Let us assume that, according to some relativistic gravitational phenomenon (to be described later), the Sun's equatorial plane is associated with an excess microwave radiation temperature, just as is evident for the plane of our galactic disk according to the empirical temperature maps in Fig. (34). Then, as the Earth pursues its annual rotation around the Sun in the Ecliptic, it must literally "thread itself through hot and cold spots." Moreover, it would generally appear that the regions of the sky on opposite sides of the Ecliptic plane would have different temperatures.

> Also, in 2003 Hans Kristian Eriksen of the University of Oslo and his co-workers presented more results that hinted at alignments. They divided the sky into all possible pairs of hemispheres and looked at the relative intensity of the fluctuations on the opposite halves of the sky. What they found contradicted the standard inflationary cosmology—the hemispheres often had very different amounts of power. But what was most surprising was that the pair of hemispheres that were the most different were the ones lying above and below the Ecliptic, the plane of the earth's orbit around the sun. This result was the first sign that the CMB fluctuations, which were supposed to be cosmological in origin, with some contamination by emission in our own galaxy, have a solar system signal in them—that is, a type of observational artifact.[74]

If our Sun is a local source of microwave radiation in this manner, then every star in our galaxy provides a similar microwave radiation source. Moreover, every galaxy produces the same real-time microwave emission shown in Fig. (34), which was subjectively eliminated from the Internal Linear Combination Map because it is inconsistent with the Big Bang paradigm. It follows that the cosmic microwave background should appear to be warmer for regions of the sky associated with high concentrations of galaxies and lower for large cosmic voids where there is a paucity of galaxies. This is precisely what is observed by our instruments. However, in the context of the Big Bang paradigm, the warm spots have been interpreted to be caused by inverse Compton scattering of assumed background CMB photons (i.e, the Sunyaev–Zeldovich effect). This is the same thing as interpreting the cosmological redshift as indicative of a recessional velocity; the astrophysical observation is accurate but the scientific explanation is wrong. The cooler spots have been interpreted as being due to the integrated Sachs-Wolfe effect (uneven CMB spectrum attributed to gravitational redshift), which is yet another example of modern "epicycles." Certainly the huge "WMAP cold spot" cannot be explained by this phenomenon.

The field of view of the *Hubble Ultra Deep Field* (HUDF) image is about 10^{-7} of the sky. Within this image, there appear to be nearly 10^4 discrete galaxies, so the HUDF suggests that there are on the order of 10^{11} distinct galaxies in the observable Universe (see *Appendix E*). Abstractly representing the total observable Universe, the circle in Fig. (35) has an area of about 8000 square millimeters as printed. Ignoring fractal effects within about $z = 0.5$, a total population of 10^{11} implies 12.5 million galaxies per square millimeter within the area of the gray circle. Recall that with no expansion there is no intrinsic difference between the nearby Universe and the high-redshift Universe. Each galaxy is a source of copious microwave radiation, as is conspicuous for the Milky Way in Fig. (34). It is not difficult to visualize that the observed cosmic microwave background radiation has nothing whatsoever to do with the purported Big Bang, which reliable evidence now suggests never occurred; the CMB has been produced continuously, arguably for an eternity, and the spatially finite Universe is an ideal blackbody.

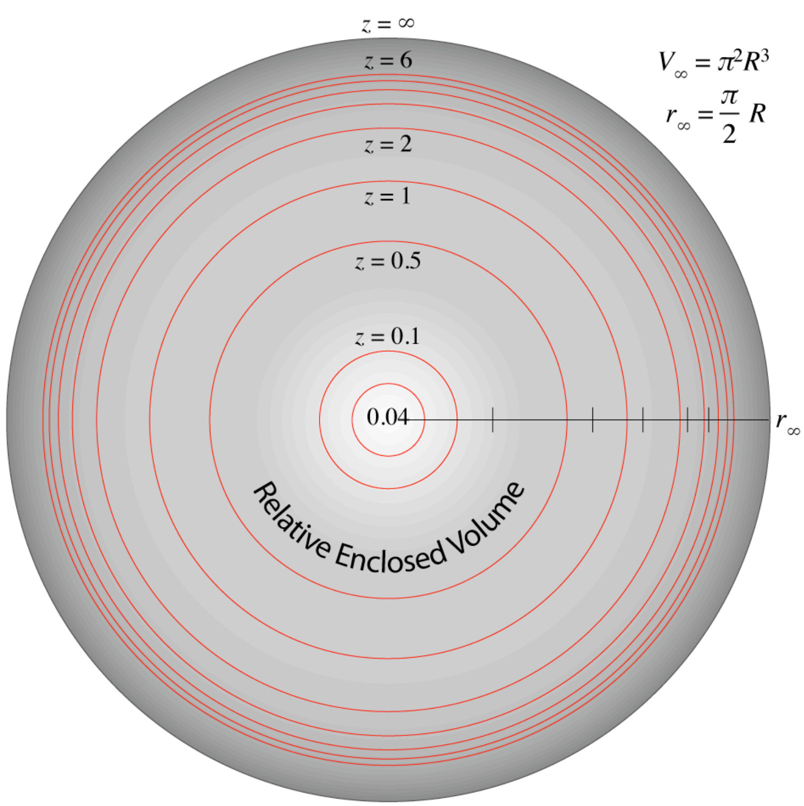


Figure 35 | Area plot of Eq. (22). The relative radial distance tick marks are at $z = 0.01, 0.5, 1, 2, 3$.

The dominant paradigm generally controls what most people see (i.e, their interpretation of perception). For centuries before Copernicus, Galileo and Kepler, astronomers observed the seasonal motion of the Sun on the horizon, the circular rotation of the stars and the more subtle retrograde motion of the “wandering” planets. These observations did not lead them to understand the simple and obvious kinematics of the Solar System. Instead, they continued to defend the intellectually primitive and illogical dominant paradigm with religious fervor. The same thing has happened in recent decades in the context of the Big Bang theory. All of the observational evidence for a correct scientific understanding of nature is available, but the intellectual and political momentum of the Big Bang theory in academia has heretofore prevented the broad realization that the theory is not only false, but utterly inconsistent with the known rational laws of physics. History has proven repeatedly that the common human condition is not just being incorrect, but the pernicious combination of false confidence, persuasive authority and extreme error in thinking, which is prevalent in religion and politics, but not entirely absent from science.

If, according to conventional wisdom, one assumes that the cosmic microwave background radiation is sourced from a cosmic creation event long ago and far away, one would never conceive of including a dynamical analysis of the microwave background. To date, the ubiquitous microwave radiation has only been analyzed in the context of spatial variation (anisotropy), with no thought whatsoever given to variation over time. However, the apparent Solar System signal discovered by research groups studying the WMAP data is quite certainly indicative of a dynamical signal modulation associated with the orbital motion of the Earth.

If energy in the form of microwave radiation is produced by dynamical gravitational systems in real time, then we must surely observe the phenomenon of energy transformation that yields the microwave background, although no causal connection between the two was ever previously suspected. There is only one possible source of the energy and this is loss of rotational kinetic energy in the form of axial spin as well as gravitational orbital motion. It will be shown that the principles of relativity imply that all spinning self-gravitating bodies must experience a secular loss of angular momentum. Similarly, even in the absence of mechanical drag, all orbits must decay due to the same relativistic effect of the gravitational field, which is associated with the fundamental concept of temporal geometry applied to accelerated reference frames. Therefore, planets slowly migrate towards their host star, which in particular cases may be counteracted by stellar angular momentum transfer, causing oscillation of the orbital radius and cyclical planetary climate change.[75] Similarly, binary stars must exhibit orbital period oscillations.[76] Conservation of energy implies that the energy dissipated by dynamical gravitational systems due to this relativistic effect, most evidently as the secular spin-down of pulsars, must manifest in some other form.[77] The observation of the ubiquitous cosmic background radiation, which can no longer be attributed to a primordial cosmic explosion, suggests that all dynamical gravitational systems lose energy, emitted as electromagnetic radiation. Moreover, the maximum brightness (i.e., temperature) of this radiation can be expected to occur in the equatorial plane of rotating systems where the tangential velocity is a maximum.

If we cannot assume a primordial source of the CMB, then an analysis of astrophysical energy budgets must reveal its realtime source. As we know more about the Earth and the Moon than any other astrophysical system, this is a good place to start. — The secular acceleration of the Moon, whereby the mean distance to the Moon is observed to be increasing by 3.8 *cm*/*yr* in the current epoch, is a well-known phenomenon, which has been accurately measured by lunar laser ranging (LLR).[78] A trivial calculation of gravitational force times distance (3.8 *m*/*cy*) reveals that the energy cost of this motion over a century is

$$W = F \cdot d = \frac{GM_E M_M}{a_M^2} \cdot 3.8 \approx 7.5 \times 10^{20}\ \text{J/cy} \tag{39}$$

According to conventional wisdom, the Moon is being boosted in its orbit due to angular momentum transfer from the Earth. If this is correct, then over a century, the Earth loses about 7.5×10^{20} joules of rotational kinetic energy in order to account for the LLR observations. There is, however, another possible explanation. Let us imagine that a heretofore unmodeled relativistic gravitational effect causes a secular dissipation of orbital energy. As the Moon is gravitationally bound to the Sun to a greater degree than to the Earth, the Earth-Moon system is more like a co-orbiting double-planet system than a satellite orbiting

a host planet. If the gravitational interaction with the Sun dominates over the Earth-Moon interaction, then this hypothetical effect will tend to cause a decay of both of their solar orbits that dominates over the same effect between the two co-orbiting bodies. As the Earth and Moon are separated by an average distance of about 384,000 *km* and on average one is closer to the Sun than the other, it is reasonable to suspect a differential decay rate of both bodies with respect to the Sun that very slowly increases the mean Earth-Moon distance.

The known geologic and biologic history of the Earth precludes the idea that the Earth-Moon barycenter has undergone an unceasing secular decay of its solar orbital radius. However, there is good evidence of cyclical planetary climate change over hundreds of millions of years between brief extreme periods of an essentially frozen "snowball Earth" and an "ultra-warm greenhouse" world.[79,80] It is then reasonable to suspect an oscillation of the Earth-Moon system's mean distance from the Sun over geologic time periods. An energy dissipation phenomenon that causes secular orbit decay counteracted by the known outward push on the Earth by the solar wind would cause just such an oscillation.

If the conventional explanation for the secular acceleration of the Moon (tidal dissipation) is correct, then the energy dissipation rate correlated with the observed spin-down rate of the Earth should closely match the energy requirement calculated in Eq. (39).

According to the NASA *Earth Fact Sheet*, the Earth's moment of inertia is

$$I = 0.3308\left(5.9736\times10^{24}\,kg\right)\left(6.3781\times10^{6}\,m\right)^2 = 8.0387\times10^{37}\ \ kg\ m^2 \tag{40}$$

Relative to an inertial frame, the Earth's axial rotation rate in the current epoch is

$$\omega_1 = \frac{2\pi}{86164.1\text{ sec}} \tag{41}$$

Over a century, the work (W) done to increase the average distance between the Earth and the Moon by 3.8 meters should accurately correspond to a decrease in Earth's angular velocity.

$$\omega_2 = \sqrt{\omega_1^2 - \frac{2W}{I}} \tag{42}$$

If the Earth were losing rotational kinetic energy to match the secular gain in the Moon's orbital energy, the resulting increase in length-of-day (lod) over a century would be about 0.15 millisecond.

$$\Delta\text{lod} = \frac{2\pi}{\omega_2} - \frac{2\pi}{\omega_1} \approx 1.5\times10^{-4}\ \text{sec} \tag{43}$$

However, from astronomical records dating back several millennia, the long-term increase in the mean length-of-day has been established to be about 2.3 milliseconds per century and data limited to the last 200 years of astronomical observations (1798–1998) implies that the mean length-of-day increase over that period was about 1.5 milliseconds per century.[81,82] As the secular acceleration of the Moon requires only a small fraction of the rotational energy dissipated by the Earth, it is conventionally assumed that the remainder (more than 3 terawatts or over 6 milliwatts per square meter of the geoid) dissipates as heat due to tidal friction, primarily occurring in a turbulent bottom boundary layer in shallow seas. Though an unlikely explanation, this was the best model previously available. However, it is now proposed that terrestrial spindown is due primarily to a previously unsuspected relativistic phenomenon, which will be introduced in the following section, and that the energy radiated from the Earth correlated with its spin-down manifests primarily in the microwave region of the spectrum. While a detailed theory of the mechanism remains to be worked out, this suspected relationship between gravity and electromagnetism is subject to empirical verification, inclusive of the prediction in Fig. (36). The empirical observation of the CMB and the absence of a primordial source (Big Bang) leads to the conclusion that it is a ubiquitous real-time emission correlated in part with the phenomenon of astrophysical spin-down as well as orbit decay.

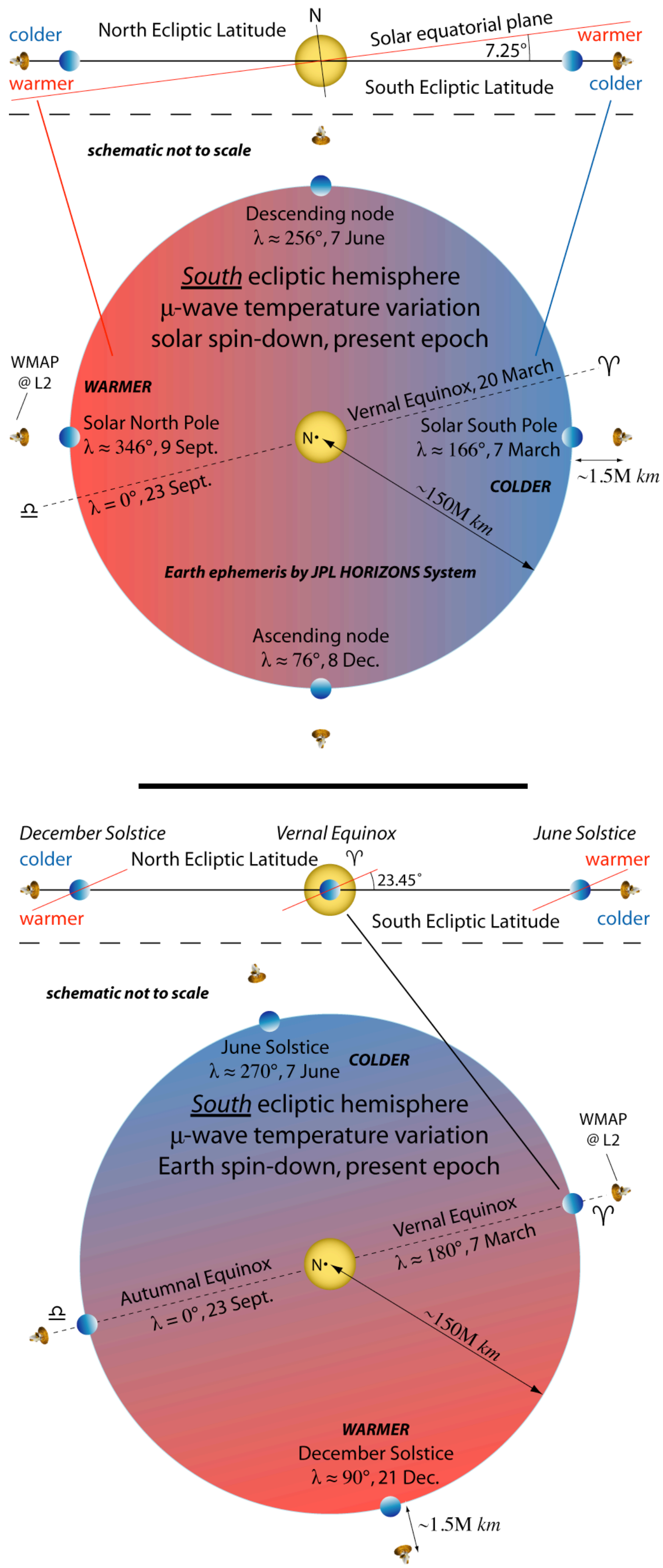


Figure 36 | Predicted μ-wave temperature variation calendars. These are the two expected dynamical signatures observing from the location of L2 in the direction of South Ecliptic latitude. Separate out-of-phase annual sinusoids are correlated to solar and terrestrial spin-down.

15. AN OVERSIGHT IN THE HISTORICAL FOUNDATION OF GENERAL RELATIVITY

This exposition provides only an introduction to this subject, yet enough information will be provided to demonstrate conclusively to a suitably broad audience that the general theory of relativity incorporates a conceptual flaw. This flaw originated with a simple logical error made at the very beginning of Einstein's effort to synthesize the principles of special relativity with accelerated reference frames. It will be shown that the conventional relativistic gravitational theory put forward by Einstein yields only a subset of all empirical implications arising from a proper synthesis.

By definition, the path of light establishes a geodesic between two points in vacuum, for there is no shorter distance between those points than that measured along this path of minimum action:

> All length-measurements in physics constitute practical geometry in this sense, so, too, do geodetic and astronomical length measurements, if one utilizes the empirical law that light is propagated in a straight line, and indeed in a straight line in the sense of practical geometry.[83]

Consider the polar coordinate system of inertial frame K (i.e., ideally free of any acceleration) shown in Fig. (37a). If we imagine that a standard measuring-rod is employed to measure the radius of K, it is imperative that this rod be carefully placed end-over-end along the shortest possible distance between the origin and the periphery (i.e., along a radial geodesic). Per Einstein's foregoing quotation, this geodesic is defined by the radial path of light, which in practice may be traced by a radial laser placed at the origin (red beam). Let the direction of the red laser designate the 0º azimuth angular reference coordinate of K. Let the number of standard rods measured over the radius along this geodesic be exactly n so that we may state that the radius of the inertial reference frame K is n standard units.

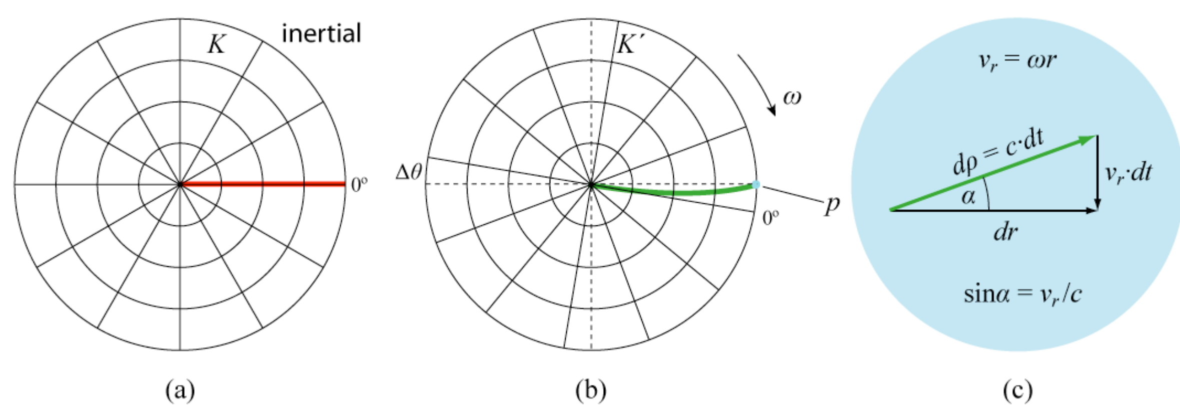


Figure 37 | The radial *geodesic* is defined by the path of a *physical* coherent light beam.

At the origin of K, let a green laser be fixed to a rotating stage with angular period P. Thus, every P seconds the green laser momentarily points in the same direction as the red laser. The direction in which this laser points, as fixed in the co-rotating coordinate system, is designated as its 0º azimuth. It should be clear that this rotating coordinate system is a mathematical abstraction representing a virtual rotating reference frame K'. Consequently, the coordinate 0º reference radial of K' sweeps out a complete circle of 2π radians in P seconds and this mathematical fact is completely independent of any physical law. Contrariwise, due to the finite speed of light, photons emanating from the green laser require some amount of time to propagate. In this time, the rotating Euclidean polar coordinate system of K' will have advanced by some angular displacement $\Delta\theta$. It is clear that at coordinate radius n as defined in K, the green laser's photons will not strike the 0º reference radial of K'. Relative to the K' coordinate system, the coherent beam of photons traveling at the limiting speed c must *curve* in relation to the local tangential velocity of K'. For illustrative purposes, this curve is exaggerated in Fig. (37b). This curve, which is defined according to the physical principles of the special theory of relativity, is designated by the variable ρ (rho), in contrast to the linear coordinate radius r, which is defined exclusively by kinematics and geometry. The local curvature of a coherent radial light beam relative to the rotating coordinate

system of K' arises due to the physical principle that the speed of light is finite and constant for all observers regardless of their motion. Consequently, the tangential velocity (v) of a rotating observer at any point p along the curved light path ρ in K' has no effect on the measured speed of the radial photons emitted by the co-rotating green laser. Consequently, one may construct the simple spatial vector diagram shown in Fig. (37c), which establishes the precise geometric relationship between dr and $d\rho$.

Let us imagine an ideally co-rotating observer in K' who wishes to measure the distance from the origin of the rotating reference frame K' to some peripheral point p. If a standard measuring-rod is employed to measure the radius of K', it is again imperative that this rod be carefully placed end-over-end along a radial geodesic, which according to the laws of physics is physically defined by a radial coherent light beam *as it is experienced to exist by the ideally co-rotating observer in* K'. This light beam is represented by the green curve in Fig. (37b), which represents the straightest possible line and the shortest distance through space, as space is experienced to exist and as it is measured in the rotating reference frame.

It is evident that for each point p in K' there are two distinct radial coordinates: the *coordinate* radius r and the distinct *physical* radius ρ. Because light cannot propagate collinear with the geometric definition of the coordinate radius r in the rotating frame, this radius is an unphysical abstraction in that frame; it is strictly a mathematical coordinate that references the corresponding physical radial coordinate as it is defined in the stationary inertial frame. The laws of physics dictate that a geometric distinction exists between the coordinate radius r and the physical radius ρ for a rotating reference frame K' [Fig. (37b)], yet no such distinction exists for a similar inertial reference frame K [Fig. (37a)].

Let an observer in an inertial frame K measure the radial distance from the origin of K to a peripheral point p as n units of a standard measuring-rod, where ($n >> 1$). Let K now incur a rotational velocity and let the observer then remeasure the radial distance from the origin of the rotating frame K' to the same peripheral point p as n' units of the standard measuring-rod. According to the principles of relativity, it is necessarily the case that n' is greater than n; the geodesic path in the accelerated frame, which is curved relative to the coordinate radius, accommodates a greater number of measuring-rods. The geometric meaning of the word "radius" as it refers to the physical measurement of a spatial interval is not identical for an inertial frame and for a rotating frame. Thus, a fundamental physical effect incurred due to centripetal acceleration is the relativistic dilation of the physical radius corresponding to a fixed coordinate radius. This implies a measured "excess radius" for a rotating frame as compared to the same inertial frame. The local differential relationship between the physical radius ρ and the coordinate radius r is precisely defined in terms of the local characteristic tangential velocity $v_r = \omega r$. Note that if there is no rotation ($v_r \equiv 0$), Eq. (45) reduces to the trivial equality applicable to the inertial frame.

$$\frac{d\rho}{dr} = \frac{1}{\cos\alpha} = \frac{1}{\sqrt{1-\sin^2\alpha}} = \frac{1}{\sqrt{1-\frac{v_r^2}{c^2}}} \tag{44}$$

$$d\rho^2 = \left(1-\frac{v_r^2}{c^2}\right)^{-1} dr^2 \tag{45}$$

According to the historical record, it is readily apparent that Albert Einstein never appreciated this subtle consequence of the principles of relativity. This is because his focus was clearly on the algebra of the Lorentz transformation equations, specifically suggesting the idea that a relative velocity is required to produce a relativistic length contraction in the context of a rotating reference frame. Since a velocity is exclusively associated with the tangential coordinate, Einstein wrongly assumed that no relativistic effects of a geometric nature applied to the radial coordinate of a rotating frame of reference, but this has been demonstrated to have been a serious oversight. When we look at the intrinsic curve of the green laser light beam relative to the K' coordinate system in Fig. (37b), whose curved geometry is precisely defined by the simple vector diagram in Fig. (37c), we are quite literally visualizing the most fundamental and accurate definition of "curved spacetime." It differs from the conventional definition in that it represents the transformation of time into space according to a physically intuitive and simply described geometry.

Historically, the rotating coordinate system K' in Fig. (37b) was imagined to be a rotating "rigid disk." This likely stemmed from a 1909 paper published by Max Born in which he discussed the relativistic treatment of rigid bodies.[84] Subsequently, Einstein's close friend and colleague, Paul Ehrenfest, put forward the idea that Born's relativistic local rigidity criterion implied that a rotating disk's circumference must incur a relativistic effect due to tangential velocity, while its radius will incur no such effect.[85] It is readily apparent that special relativity requires a standard measuring rod along the periphery of a rotating frame to contract relative to the inertial frame due to its tangential velocity. Consequently, Einstein argued that the conventional Euclidean ratio between radius and circumference does not hold for a rotating reference frame. Although this conclusion was correct, Einstein's methodology was flawed; he failed to see how the Equivalence Principle must lead immediately to valid quantitative geometric relationships applicable to a real gravitational field. In the context of the Equivalence Principle, a rotating frame of reference, while limited to 2-dimensional space, is an almost perfect analogy to a real gravitational field, assuming a static symmetric field (i.e., the Schwarzschild assumptions).

For some years prior to Ehrenfest's paper, a young Einstein (he turned 30 that year) tried and failed to find a synthesis between special relativity and gravity. Ehrenfest's flawed insight clearly electrified him. Einstein put forth the following seemingly cogent argument in his popular book on relativity in the section entitled "Behavior of clocks and Measuring-Rods on a Rotating Body of Reference."

> If the observer applies his standard measuring-rod (a rod which is short as compared to the radius of the disc) tangentially to the edge of the [rotating] disc, then, as judged from the Galileian system [inertial frame K], the length of this rod will be less than 1, since, according to Section 12, moving bodies suffer a shortening in the direction of the motion. On the other hand, the measuring-rod will not experience a shortening in length, as judged from K, if it is applied to the disc in the direction of the radius. If, then, the observer first measures the circumference of the disc with his measuring-rod and then the diameter of the disc, on dividing the one by the other, he will not obtain as quotient the familiar $\pi = 3.14\ldots$, but a larger number, whereas of course for a disc that is at rest with respect to K, this operation would yield π exactly. This proves that the propositions of Euclidean geometry cannot hold exactly on the rotating disc, nor in general in a gravitational field, at least if we attribute the length 1 to the rod in all positions and in every orientation.[86]

He points out in a footnote that the laws of special relativity hold exclusively for the inertial system K.

> Throughout this consideration we have to use the Galileian (non-rotating) system K as reference body, since we may only assume the validity of the results of the special theory of relativity relative to K (relative to K' a gravitational field prevails).[87]

The historical record makes it clear that the analysis of a rotating rigid disk in the context of special relativity played a pivotal role in the development of general relativity. Early on in the pursuit of the theory, in a letter to Arnold Sommerfeld dated 29 September 1909, Einstein writes:

> The treatment of the uniformly rotating rigid body seems to me to be very important because of an extension of the relativity principle to uniformly rotating systems by trains of thought which I attempted to pursue for uniformly accelerated translation…[88]

In "Part 3" of his 1916 *Annalen der Physik* paper on general relativity, Einstein writes about a system of coordinates K' in uniform rotation relative to an inertial reference frame K:

> …we envisage the whole process of measuring [in K'] from the "stationary" system K, and take into consideration that the measuring-rod applied to the periphery undergoes a Lorentzian contraction, while the one applied along the radius does not. Hence Euclidean geometry does not apply to K'.[89]

In a 1921 lecture to the Prussian Academy of Sciences entitled "Geometry and Experience," Einstein made it clear that *the decisive step* leading to the method employed to develop his system of equations describing gravitation was Ehrenfest's interpretation of the rotating disk.

> In a system of reference rotating relatively to an inertial system, the laws of disposition of rigid bodies do not correspond to the rules of Euclidean geometry on account of the Lorentz contraction; thus if we admit non-inertial systems on an equal footing, we must abandon Euclidean geometry. Without the above interpretation the decisive step in the transition to generally covariant equations would certainly not have been taken.[90]

Ehrenfest's original analysis of a rotating rigid disk in the context of special relativity clearly motivated Einstein's thought process, leading to his eventual conception of general relativity. What Einstein was searching for in the years 1907 to 1909 was a way to tackle the synthesis between special relativity and acceleration (i.e., *gravitation*). Ehrenfest's imagined rotating rigid physical disk (an accelerated reference frame that exhibits relativistic effects that can also be interpreted in the context of special relativity) offered a panacea. This is because the Equivalence Principle implies that what is generally true for a rotating centripetally accelerated observer is also true for an observer experiencing the radial acceleration of a gravitational field. The radial relativistic effects of the gravitational field (i.e., *excess radius*) are effectively duplicated for the inertially accelerated rotating frame of reference, but Einstein failed to notice this in 1909 or any time thereafter. The superficial principle that Einstein adopted based on an erroneous analysis of the rotating frame analogy to gravity was the idea of non-Euclidean spatial geometry. The essential idea that Einstein failed to appreciate was the transmutation of time into space for the rotating 'disk' and indeed all accelerated frames of reference, including a gravitational field.

Using a suitable instrument such as a gyroscope over some interval of time, a centripetally accelerated rotating observer can determine that the acceleration experienced is an inertial acceleration. However, if measurement is restricted to a single moment, then this measurement cannot distinguish between inertial and gravitational acceleration. Accordingly, although in fact moving as perceived by inertial observers and by a local instrument over time, the rotating observer is entitled to the opinion that no such motion exists and to interpret the measured acceleration as the effect of a peculiar kind of "gravitational field." Thus, the Equivalence Principle allows a rotating frame of reference K' with its associated system of coordinates to function as an accurate analog to a real gravitational field. — In the words of Einstein,

> But, according to the principle of equivalence, K' may also be considered as a system at rest, with respect to which there is a gravitational field… We therefore arrive at the result: the gravitational field influences and even determines the metrical laws of the spacetime continuum.[91]

Willem de Sitter had more to say on the matter.

> In Einstein's theory of general relativity, there is no essential difference between gravitation and inertia. The combined effect of the two is described by the fundamental tensor $g_{\mu\nu}$, and how much of it is to be called inertia and how much gravitation is entirely arbitrary. We might abolish one of the two words, and call the whole by one name only. Nevertheless, it is convenient to continue to make a difference. Part of the $g_{\mu\nu}$ can be directly traced to the effect of known material bodies, and the common usage is to call this part "gravitation" and the rest "inertia."[92]

Correctly employed in the context of a rotating frame of reference, the Equivalence Principle is magnificent in its ability to produce a penetrating understanding of the gravitational field. A rotating observer who, according to the Equivalence Principle, is entitled to interpret the experience of inertial acceleration as a kind of "gravitational field," is equally entitled to identify the locally measured "gravitational acceleration" at an eccentric point p with a characteristic "escape velocity" energy value associated with that point. The concept of escape velocity indirectly refers to a kinetic energy equivalent to the local gravitational potential energy. In the case of a rotating frame of reference, conservation of energy implies that this characteristic velocity, which is essentially an abstract mathematical property associated with a coordinate radius r, is identical in magnitude to the real physical tangential velocity at radius r measured by an inertial observer. If this is not immediately clear, then it can be shown explicitly by integrating the centripetal acceleration over an arbitrary coordinate radius r. The work done on a particle of arbitrary mass m ideally translated from the disk center to radial coordinate r must always equal the particle's kinetic energy of rotation due to its tangential velocity v_r at r. In the non-relativistic regime, where m is taken to be a constant,

$$\int F \cdot dr = m\int \frac{(\omega r)^2}{r}\,dr = m\omega^2 \int r\,dr = \frac{1}{2}m\omega^2 r^2 = \frac{1}{2}mv_r^2 \tag{46}$$

Eq. (46) and the Equivalence Principle imply that the role of the variable v_r in Eq. (45) is indistinguishable from the role of characteristic escape velocity ($v_r \equiv v_{esc}$). Then Eq. (45), which was derived exclusively in reference to a rotating frame of reference, can be written as Eq. (47).

$$d\rho^2 = \left(1 - \frac{v_{esc}^2}{c^2}\right)^{-1} dr^2 \tag{47}$$

In the case of inertial acceleration due to rotation,

$$v_{esc} = \omega r \tag{48}$$

and in the case of real gravitational acceleration due to a source mass *M*,

$$v_{esc} = \sqrt{\frac{2GM}{r}} \tag{49}$$

Upon substituting the latter definition, Eq. (47) takes on a familiar form found in standard textbooks of general relativity relating the physical radius of a gravitational field (ρ) to its coordinate radius (r).

$$d\rho^2 = \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 \tag{50}$$

The derivation of Eq. (50) from Eq. (45) is clearly a direct consequence of the Equivalence Principle and confirms that Einstein made a significant mistake in accepting Ehrenfest's assumption that no spatial relativistic effect occurs in the direction of the radius for a rotating frame of reference. This should have been obvious, for there can be no radial relativistic temporal effect without a corresponding spatial effect.

Recall Minkowski's assertion that spacetime is composed of an "infinite number of spaces." This claim is made manifest in the case of a rotating frame of reference because the neighborhood of each unique point over a geodesic interval ρ constitutes a distinct space with each space being distinguished by a unique value of the characteristic angle α as defined in Fig. (37c). This is also the angle between the local proper time coordinate and the time coordinate of an inertial observer at $r = 0$. Naturally, each of these distinct spaces is associated with a geometrically unique local time coordinate.

The term "proper time" commonly employed in relativistic physics is a kind of malapropism referring to Henri Poincaré's term "propre temps." In the French, the literal meaning of "votre propre temps" is "your own time."[93] Then *proper time* refers to the time indicated by an ideal clock in the rest frame of any particular observer whose relativistic perspective is being considered. In a rotating frame of reference, the time t at the radial coordinate $r = 0$ corresponds to the proper time of an ideal inertial observer O who experiences no centripetal acceleration. As this observer has the unique inertial perspective for all points on K', the time t designates "coordinate time" in like manner to the "coordinate radius," which designates the physical radial coordinate as measured in inertial space. The time at some eccentric point at a coordinate radius r in K', designated τ_r, corresponds to the proper time of a local ideally co-rotating observer O' who measures a centripetal acceleration at that location. According to O, the only *observable* applicable to O' is the measured tangential velocity v_r. Consequently, the inertial observer O is entitled to apply the principles of special relativity to this observation and to conclude that the rate of proper time for O' is less than the rate of local proper time according to Eq. (51).

$$\frac{dt}{d\tau_r} = \frac{1}{\sqrt{1 - \frac{v_r^2}{c^2}}} \tag{51}$$

Again, recognizing the identity ($v_{esc} \equiv v_r$) and rearranging the terms so as to produce an expression for local proper time (τ) in terms of the coordinate time (t) puts this equation in similar form to Eq. (47).

$$d\tau^2 = \left(1 - \frac{v_{esc}^2}{c^2}\right) dt^2 \tag{52}$$

Upon substituting the gravitational definition of escape velocity, Eq. (52) takes on a familiar form found in standard textbooks of general relativity relating the local proper time in a gravitational field (τ) to the coordinate time (t).

$$d\tau^2 = \left(1 - \frac{2GM}{rc^2}\right) dt^2 \tag{53}$$

Consider now an observer experiencing ideal radial free-fall in a gravitational field. Consequently, the angular parameters (θ, ϕ) are constant and can be ignored. With the exception of arbitrarily small gravitational tidal forces, this free-falling observer can make no local measurements that indicate absolute motion; there is nothing internal to a locally Lorentzian free-falling reference frame to indicate a state of acceleration relative to a gravitational source mass. Consequently, the space-time metric for the inertial free-falling observer corresponds to the Minkowski metric in terms of local measurable coordinates.

$$ds^2 = -c^2 d\tau^2 + d\rho^2 \tag{54}$$

Equations (50) and (53) correlate these local proper space and time coordinates to the convenient reference coordinates of the gravitational field (i.e., the coordinate radius and the coordinate time). Substitution yields the first two terms of the familiar Schwarzschild metric for an ideal static symmetric gravitational field. Per the concept of temporal geometry developed in the previous sections, one is not entitled to assume that the local time coordinate of the metric is independent of angular coordinates (θ, ϕ).

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right) c^2 dt^2 + \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 \tag{55}$$

Max Born, Paul Ehrenfest, Albert Einstein and numerous theoretical physicists who followed them made the fundamental mistake of imagining K' to be a kind of a physical object (i.e., a "rigid disk") instead of a purely abstract mathematical object (i.e., a virtual disk) that can be used to model the laws of mathematical physics. Is not a polar coordinate system by its very mathematical nature perfectly "rigid"? Then, as shown in Fig. (38), the periphery of the abstract coordinate system may spin with a virtual tangential velocity (i.e., not an actual physical velocity) of the speed of light (c).

As quoted in his book, *The Meaning of Relativity*, the following is a reiteration of young Einstein's erroneous analysis of the rotating frame of reference, which eventually led him to his ingeniously conceived yet seriously flawed concept of "spacetime curvature."

> Imagine a circle drawn about the origin in the $x'y'$ plane of K', and a diameter of this circle. Imagine, further, that we have given a large number of rigid rods, all equal to each other. We suppose these laid in series along the periphery and the diameter of the circle, at rest relatively to K'. If U is the number of these rods along the periphery, D the number along the diameter, then, if K' does not rotate relatively to K, we shall have $U/D = \pi$. But if K' rotates we get a different result. Suppose that at definite time t, of K we determine the ends of all the rods. With respect to K all the rods upon the periphery experience the Lorentz contraction, but the rods upon the diameter do not experience the contraction (along their lengths!). It therefore follows that $U/D > \pi$.[94]

Herein there are two fallacies. The first is that the geometric meaning of *physical radius* is identical for the distinct reference frames K and K'. This significant logical error has already been discussed in detail. The second fallacy is that the contraction of measuring rods along the periphery of K' implies an *increase* in the effective circumference of the reference frame. Quite the contrary, it is clear that the physical interpretation of the coordinate transformation implies a relativistic *contraction* of the circumference according to Eq. (56).

$$C'(r) = 2\pi r \sqrt{1 - \frac{v_r^2}{c^2}} \tag{56}$$

Normalizing the speed of light (c = 1), angular velocity (ω = 1) and maximum radius (R = 1) yields the effective radius of circumference (r') as a function of the coordinate r, which is graphed in Fig. (39).

$$r'(r) = r\sqrt{1 - r^2} \tag{57}$$

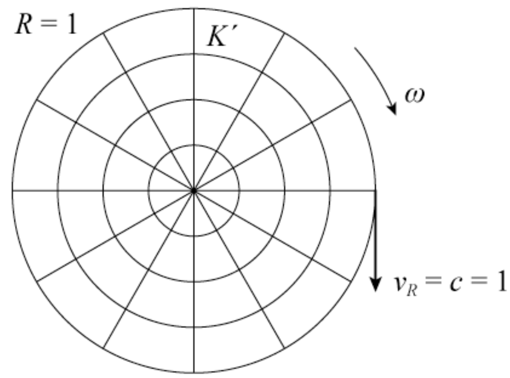


Figure 38 | The coordinate system K' as a *mathematical* object. The peripheral tangential velocity at maximum radius (R = 1) is the normalized limiting speed c. Applying the relativistic length contraction formula to the circumference (C), this perimeter is reduced to a point (i.e., a pole).

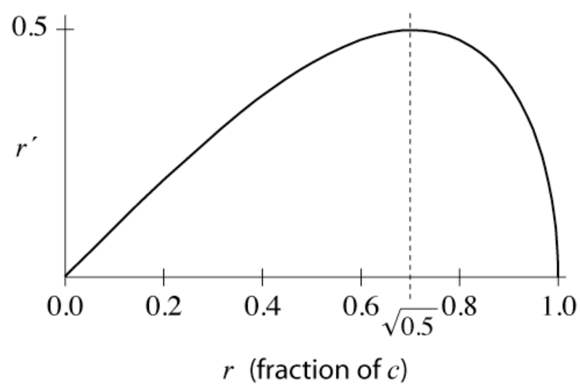


Figure 39 | Graph of Eq. (57).

It becomes clear that due to the phenomenon of "spacetime curvature" induced by acceleration whereby "time becomes space," the coordinate r = 1 is a pole, similar to the coordinate r = 0. The outer circle of Fig. (38) collapses to a single point according to the mathematics. The part of our mind that evaluates reality according to visual logic tends to reject the idea that the perimeter of K' corresponds to a single point. It would then seem that the entire virtual disk must collapse to a single point because we think of the perimeter as enclosing an interior 2-dimensional *space*. However, the virtual disk in Fig. (38) is actually a 2-dimensional mapping of a 3-dimensional subset of *spacetime* restricted to an x-y plane of 3-space. Per the existence of the "infinite number of spaces" revealed by Minkowski, it proves to be the case that the neighborhood of each point on K' represents a distinct space with a distinct time coordinate. The physical picture is that the rotating virtual disk represents a kind of spatial wormhole (with radius r') through the time dimension of the inertial observer (i.e., "time becomes space"). The same physical and geometric principles must hold for a real gravitational field according to the Equivalence Principle, although the radial orientation of the relativistic effect is reversed (i.e., it is in the inbound direction).

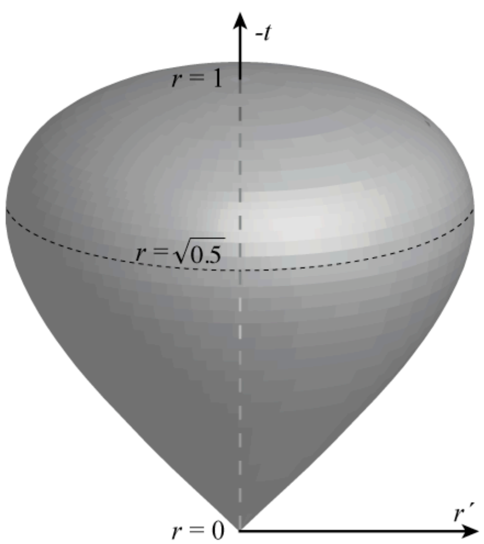
There is another way to show that the coordinate $r = 1$ in Fig. (38) collapses to a single point, which is more physically intuitive than Eq. (57). — Consider the fact that the tangential velocity of a rotating observer as measured by an inertial observer and also as measured in the rotating frame according to a gyroscope is equal to the circumference of the rotation divided by the time required for one revolution.

$$v = \frac{C}{dt} \qquad v' = \frac{C'}{d\tau} \tag{58}$$

As the relative velocity of an ideal clock (from the perspective of the inertial observer) or the equivalent escape velocity (from the perspective of the rotating observer) approaches the speed of light, the absolute rate of the rotating clock relative to an inertial clock approaches zero. In order for the tangential velocity to asymptotically approach the speed of light in such a way that both observers agree on its magnitude, the magnitude of the measured circumference of rotation in the rotating frame must also approach zero (i.e., a point) in correspondence with the relative clock rate; the physical circumference in the accelerated frame ($C' = 2\pi r'$) *must* contract relative to the coordinate circumference ($C = 2\pi r$).

$$v \equiv v' \quad \rightarrow \quad \frac{C}{C'} = \frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \frac{v_{esc}^2}{c^2}}} \tag{59}$$

In the context of spacetime and the idea that relativity implies that "time becomes space," the virtual disk in Fig. (38) can be visualized as a 3-dimensional surface having a cylindrical symmetry around the inertial frame's time axis (t), rather than a 2-dimensional surface with a circular symmetry around the inertial frame's z-axis. The latter model is a simplistic interpretation lacking mathematical sophistication. Relative to the inertial clock, the measured rate of an ideal clock slows as a function of the coordinate radius of K', so it should be clear that with increasing coordinate radius in K', we are going *back in time* relative to the inertial time coordinate. Consequently, the time axis in Fig. (40) must have a negative sign.



At escape velocities exceeding about $0.707c$, the correlated relativistic effects of length contraction and time dilation cause a decrease in the effective radius of circumference with increasing coordinate radius. Note that the centripetal (i.e., "gravitational") acceleration experienced by a rotating observer is inversely proportional to r' rather than r, so this escape velocity represents a critical instability point.

Figure 40 | The virtual 2-D disk of Fig. (38) represented as a 3-D surface in spacetime.
The curvature of the physical radius ρ relative to the coordinate radius r represents the conversion of K-frame time into K'-frame space. While each subsequent concentric differential circle of increasing radius in K' is mathematically and visually coplanar in inertial space, according to the principles of relativity these circles are not concentric (i.e., coplanar) in *spacetime*. Rather, the increasing velocity of each successive circular differential element of K' implies a further displacement of each of these successive rings in the negative direction of the inertial time coordinate. "Time becomes space."

16. A NEW LOOK AT THE GRAVITATIONAL BENDING OF LIGHT

The empirical prediction that brought Einstein rapid worldwide fame in November 1919 concerned the bending of light by a gravitational field according to his published 1916 formula (60).[95,96] It predicts a deviation of about 1.75" of arc for light grazing the surface of the Sun where b is the "impact parameter" or radius of closest approach to the centroid of the source mass (in this case the solar radius). This was a correction to an erroneous earlier prediction of half this value that Einstein made in 1911.[97]

$$\alpha = \frac{\kappa M}{2\pi\Delta} = \frac{4GM}{bc^2} \tag{60}$$

Although it makes an accurate prediction in the weak field, this equation is known to be a kind of mathematical hack, for it is not a general formula applicable to the phenomenon. As Eq. (60) obviously fails to be meaningful in the strong field limit (yielding a value of two radians at the Schwarzschild radius), this weak-field formula is an accurate but naïve approximation to a general gravitational lensing formula, which Einstein never put forward. The correct completely general formula may be derived directly from first principles, pure geometry and symmetry considerations.

As shown with illustrative exaggeration in Fig. (41), an ultra-high eccentricity hyperbolic trajectory is geometrically equivalent to bending a linear trajectory through a very small angle. The asymptotes of a hyperbolic trajectory of eccentricity e intersect at the angle α quantified by Eq. (61). This is a *definition* arising from pure geometry. As both the inbound and outbound asymptotes represent linear trajectories, the original inbound linear trajectory is effectively "bent" through this precise angle.

$$\alpha = 2\sin^{-1}\frac{1}{e} \tag{61}$$

Due to the small-angle approximation ($\sin x \approx x$), Einstein's empirically verified 1915 formula can be written in this new form. For the typically weak astrophysical fields for which this formula is known to be exclusively applicable, there are no measurable consequences.[98]

$$\alpha = 2\sin^{-1}\left(\frac{2GM}{bc^2}\right) \tag{62}$$

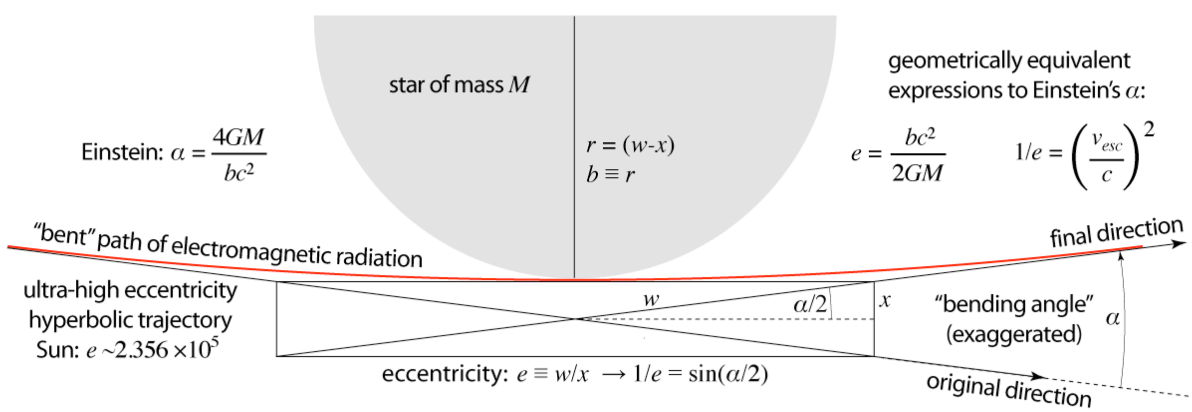


Figure 41 | Gravitational light bending modeled by a hyperbolic trajectory.
The foundations of astrodynamics require orbital trajectories to follow conic sections. The applicable conic section is dependent exclusively on the relationship between the velocity of the orbiting particle and the maximum escape velocity incurred during the orbit. A hyperbolic escape trajectory is implied when the orbital velocity exceeds this escape velocity. Because the speed of a photon is typically much greater than escape velocity ($c >> v_{esc}$) this is the implied trajectory for radiation.

Combining Eq. (61), which is simply a geometric identity, and Eq. (62) yields the eccentricity of the hyperbolic trajectory of electromagnetic radiation in a weak gravitational field. Then the inverse of this characteristic eccentricity is the square of the ratio of the escape velocity at b to the speed of light.

$$e = \frac{bc^2}{2GM} \quad \rightarrow \quad \frac{1}{e} = \frac{v_{esc}^2}{c^2} \tag{63}$$

Einstein's light bending formula is naïve in two ways. First, it does not provide a general solution and second, it does not realistically model the phenomenon as a smooth process acting over the entire photon trajectory, which must be the case. With no reference to the mass of an orbiting particle, the geometric foundations of astrodynamics specify that when the periapsis velocity of a particle is equal to the local gravitational escape velocity, the trajectory is parabolic. A parabolic trajectory (e = 1) implies parallel asymptotes, which means that the angle through which the trajectory is bent is exactly *pi* radians (180º). Although Eq. (63) is effectively identical to conventional relativity in the weak field, it is consistent with the geometric foundational of astrodynamics in the strong field limit and inconsistent with the predictions of the Einstein field equations. It can be readily demonstrated that the strong field limit prediction yielded by the field equations is incorrect because Eq. (63) is consistent with first principles [Fig. (42)].

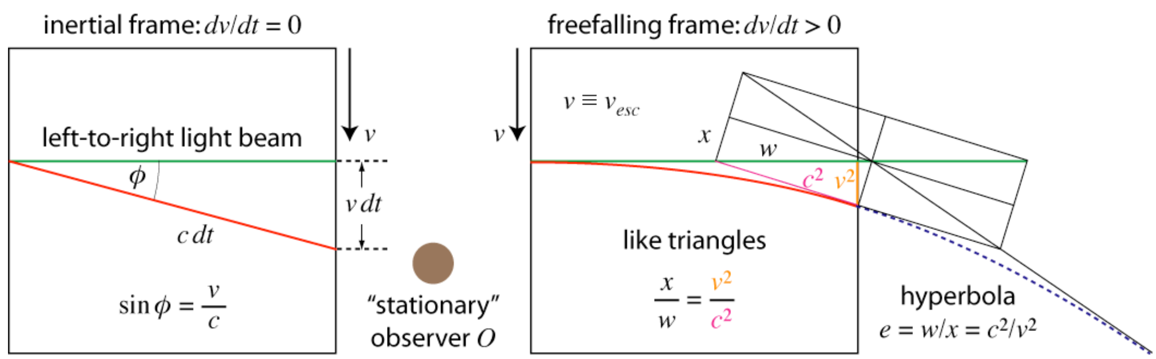


Figure 42 | Gravitational light bending derived from first principles.
The "stationary" observer (O) is independently applied to both cases. — *Left*: O feels no acceleration. In special relativity, O experiences a horizontal light beam as experienced in the uniformly 'moving' inertial frame to translate with speed c at a fixed angle *phi*. The relativistic effects are symmetrical. *Right*: O feels acceleration (i.e., the local surface gravity associated with v_{esc}). O experiences a horizontal light beam as experienced in the radially free-falling inertial frame to curve. The *asymmetry* of relativistic effects (time dilation and length contraction) requires O to apply a unilateral *second* factor of v/c to the sine ratio of v/c that appears in the symmetric SR case. The applicable velocity of the free-falling frame is the local escape velocity of the gravitational field measured by O.

The kinematics of the virtual "light clock" in the left frame of Fig. (42) lead to the simple derivation of relativistic time dilation in SR. The kinematics shown on the right lead to the natural conclusion that the bending of light in a gravitational field corresponds to a hyperbolic trajectory of precisely known eccentricity. Both are based on incontrovertible first principles. At any moment in time (i.e., speed v), the unaccelerated observer in the free-falling frame (*right*) is entitled to invoke special relativity in reference to the 'stationary' observer's accelerated frame of reference; however this is not reciprocal. Observer O experiences gravitational acceleration and so cannot invoke special relativity, so the measurement of relativistic time dilation and length contraction effects are asymmetrical; from the point of view of O, ideal clocks in the free-falling frame run fast and radial standard measuring rods are longer relative to local ideal references. Free-falling from infinity, the velocity of the 'moving' frame is identical to the gravitational escape velocity locally measured by O. The total curvature of the light beam evaluated at that point represents exactly half of the total curvature of a grazing trajectory due to the symmetry of the outbound trajectory to the inbound trajectory. — Flaws in the original conception of general relativity create modeling errors of increasing magnitude as the escape velocity approaches the speed of light.

17. TRANSVERSE GRAVITATIONAL REDSHIFT (*TGR*)

Based on seminal ideas gained from what has been revealed to be a flawed analysis of a rotating frame of reference in the context of relativity, a young Albert Einstein reinitiated his attempt to synthesize the principles of special relativity with accelerated reference frames in 1909. It is apparent that while these ideas provided the insight leading to a metric theory of gravity, the most important simplifying theoretical idea arising from Minkowski's mathematical formulation of special relativity (i.e., temporal geometry) eluded Einstein. It is not difficult to imagine that, had he lived longer, Minkowski would have approached the problem of general relativity differently and with rapid success. Moreover, given that a relativistic spatial effect transverse to the gravitational gradient is clearly implied by the analysis in *Section 15* herein, a corresponding temporal effect must exist.

An equipotential surface is a fundamental concept in Newtonian mechanics and a familiar part of practical life in the context of the Earth's gravitational field. For example, a level is commonly employed to ensure that a surface has no incline. It is currently assumed that if such a surface is ideally frictionless, no energy cost is incurred for translation across its surface. It can be readily demonstrated that the principles of relativity imply that the Newtonian concept of a gravitational equipotential surface does not exist in nature; assuming an ideal static symmetric gravitational field, there is an energy cost for lateral translation of mass-energy at constant Newtonian potential. This phenomenon of the gravitational field is similar to the cosmological redshift in that it is related to relativistic temporal geometry. For distinct spatial radials, the local time coordinates at the same coordinate radius are not parallel in spacetime. Consequently, there exists a symmetric energy differential (i.e., a redshift) between any two such points. The Equivalence Principle implies that this transverse gravitational redshift (*TGR*) must also occur in the case of inertial acceleration. —

It is easily shown and has long been well understood that an acceleration gradient causes an ideal clock at a higher potential to record time at a faster absolute rate than a similar ideal clock at a lower potential. If, as shown in Fig. (43), we mount ideal clocks in the nose (A) and the tail (B) of a rocket accelerating through ideal gravity-free space, then according to an observer watching the rocket from an external inertial vantage point, the light travel time from B to A is constantly increasing and the light travel time from A to B is constantly decreasing. Consequently, an observer at B will perceive the clock at A to flash faster than the local clock. Contrariwise, an observer at A will perceive the clock at B to flash slower than the local clock. It may be concluded that, due to the acceleration gradient, time passes faster in region A than in region B. Due to the acceleration of the rocket (g) during the propagation time of a photon between the clocks (h/c), clock A incurs a recession velocity (gh/c) relative to clock B at the time of its photon emission. Contrariwise, clock B incurs an approach velocity of the same magnitude relative to clock A at the time of its photon emission. For the condition ($\Delta v \ll c$), the inertial observer computes a relativistic Doppler effect that is proportional to $\Delta v/c$, which is gh/c^2. The Equivalence Principle implies that the identical effect must occur in a real gravitational field for clocks separated by a vertical height h. In this case, the inertial observer is in radial free fall in the gravitational field, so the clocks incur the same relative motion as when they were mounted in the rocket accelerating through gravity-free space relative to an inertial observer in that space. Richard Feynman discussed this elegant gedanken experiment in the second volume of his famous *Lectures on Physics*, which were given to a freshman class at Caltech.[99]

The Equivalence Principle is among the most significant and illuminating ideas ever put forward in the history of theoretical physics. It is also one of the simplest and most intuitive concepts in all of science. To reiterate with precision, this principle states that for a sufficiently localized reference frame in which the existence of gravitational tidal forces can be ignored within its boundaries, inertial and gravitational acceleration are indistinguishable. Because one cannot make a local measurement that can distinguish between inertial and gravitational acceleration, then whatever can be logically deduced to be true in one case according to first principles, must also be true for the other case. Theory leads to concrete experiments in which predicted reproducible effects can be measured. In exemplary fashion, the 1964 Pound-Snyder experiment after Pound-Rebka (1959) revealed that the radial gravitational redshift first predicted by Einstein was a true and accurately quantified empirical phenomenon. The experiment measured the *difference* between the gravitational redshift and the blueshift, which accounts for the factor 2 in the quotient appearing in the following reference from the literature.

Recoil-free resonant absorption of the 14.4-keV γ ray in Fe^{57} has been employed to measure the effect of gravity over a 75-ft vertical path in the Jefferson Laboratory, in an improved version of the experiment of Pound and Rebka. A Co^{57} source, initially 1.25 Ci, large-windowed proportional counters, and an enriched absorber foil 15 in. in diameter permitted a much increased counting rate. The employment of temperature-regulated ovens for source and absorbers and a redesigned monitor system to detect variations in waveform of the source velocity effected a reduction in systematic uncertainties. The result found was (0.9990+/-0.0076) times the value 4.905×10^{-15} of $2gh/c^2$ predicted from the principle of equivalence. The range given here is the statistical standard deviation set by the number of counts involved. An estimated limit of systematic error is 0.010. [100]

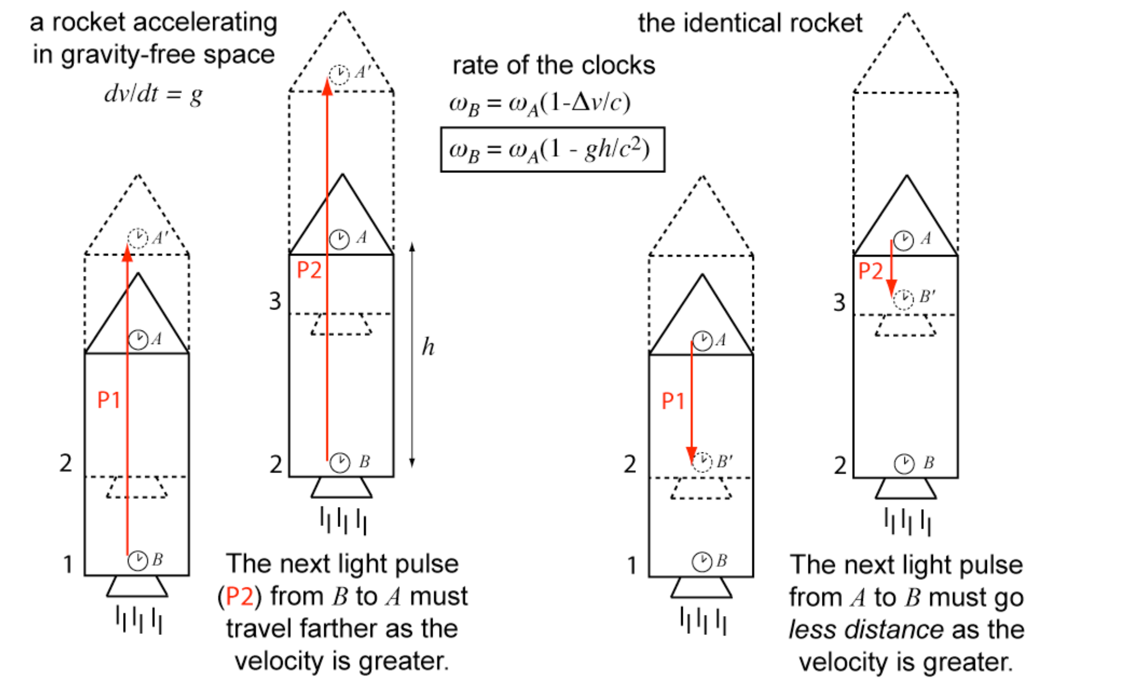


Figure 43 | Inertially accelerated ideal clocks A and B tick with flashes of light. The constancy of the speed of light implies that, over a given period of time, a free-falling inertial observer sees fewer flashes (clock ticks) arrive at clock A sourced from clock B than those that arrive at clock B sourced from clock A. Consequently, clock B ticks slower than clock A in an absolute sense.

Physicist Frank Potter reports that Richard Feynman entered a classroom at Caltech circa 1965 and presented the students (including Potter) with the gedanken experiment shown in Fig. (44).[101] The exercise was intended to pass the time due to a tardy scheduled instructor. The identical principle that applies in Fig. (43) also applies to two laterally displaced ideal clocks with the same coordinate on the vertical axis. Feynman never pursued this idea, perhaps because the naïve calculation yielded a value that appeared to be immeasurable. The "common sense" concept of a gravitational equipotential surface is so fundamental a part of the foundation to a physics education that it is natural to assume that nothing can destroy it. However, prior to Copernicus, it was thought that nothing could destroy the common sense concept that all observed heavenly bodies turn around the Earth. Similarly, prior to Einstein's 1905 special relativity paper, it was thought that nothing could destroy the common sense concept of absolute time.

An ideal geoid, locally represented by a horizontal line as defined by a level in a gravitational gradient, is conventionally assumed to be an equipotential surface, yet this assumption is invalid according to relativistic physics. — As shown in Fig. (44), two clocks rest on the floor of a rocket accelerating in gravity-free space. The clocks are separated by a horizontal distance d, so from the perspective of an observer in the rocket, the time for light to travel from one clock to the other is d/c. However, from the perspective of an inertial observer, each clock tick sends out a pulse of light that emanates from the point of emission as a spherical wavefront expanding at the speed of light from that point in space. During the

light travel time between the clocks, each clock is seen to race away from the wavefront produced by the tick of the other clock, although not directly away from it. However, it is clearly the case that the time required for a flash of light from clock *A* to catch up with clock *B* increases with each subsequent tick of the clock. This is because the speed of the rocket is increasing with time, so the distance between the point of light emission from clock *A* and the point of light absorption at clock *B* increases with each flash. The relationship between the clocks is symmetric; the same can be said for clock *B* relative to clock *A*. Although the geometry is different and a symmetry exists, the physical principle at work is identical to the familiar case of an inertial observer seeing clock *A* racing away from clock *B* in Fig. (43).

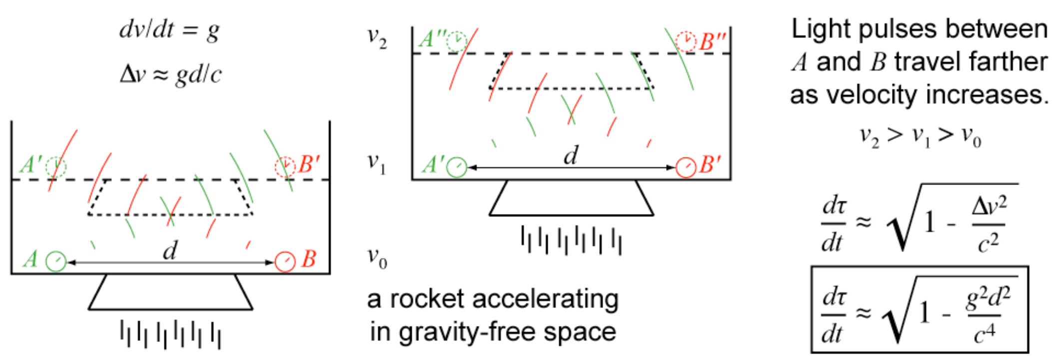


Figure 44 | Inertially accelerated ideal clocks *A* and *B* tick with flashes of light. The constancy of the speed of light implies that an inertial observer sees subsequent flashes sourced from either clock to take a longer time to reach the other clock than the previous flash. It follows that flashes from the remote clock ($d\tau$) arrive at a rate that is less than the local flash rate (dt). Consequently, the remote clock ticks slower than the local clock in a relative sense (i.e., the effect is symmetric).

In observing a pulse of light exchanged between the clocks over time Δt, the inertial observer clearly experiences the target clock to be in a different frame of reference (i.e., moving at a higher velocity) than the source clock. Due to their training in Newtonian mechanics, observers inside the rocket are inclined to assume that the two clocks on the floor of the accelerating rocket are in the same reference frame, because no local experiment can distinguish the location of clock *A* from the location of clock *B*. Also, unlike the situation in Fig. (43), in which there is a conspicuous potential between *A* and *B*, in this case there is no such immediately obvious physical distinction between them. Yet, according to the principles of relativity, it may be concluded that due to the acceleration gradient, time passes faster at the local clock relative to the remote clock and that this relativistic time dilation effect is symmetric in the same fashion as in special relativity. Due to the acceleration of the rocket (g) during the propagation time of a photon between the clocks ($\Delta t = d/c$), each clock incurs a velocity ($\Delta v = gd/c$) relative to the other clock at the time of its photon emission. Consequently, an inertial observer computes a relativistic transverse Doppler shift for which the ratio $\Delta v/c$ is squared; a very subtle symmetric redshift exists between *A* and *B*.

This fundamental relativistic phenomenon, which rests on first principles and which can be so simply demonstrated, is an unconventional addition to relativistic physics. That it was never discussed in the literature for almost a century is likely to be something of an embarrassment to professional academics in the field. (Similarly, it was an embarrassment to the Aristotelian professors of the early 17th century, who were Galileo's contemporaries, that they had overlooked the simple and now obvious fact that the Sun is located at the center of the Solar System.) Consequently, there is a tendency for physicists to be incredulous and to attempt to demonstrate that the simple physical argument presented in Fig. (44) must be incorrect. The typically invoked conventional metric is flawed because it models time incorrectly.

A fallacious argument that was presented by one critic contends that because the receiving clock (*R*) is moving faster than the transmitting clock (*T*) at the time *T* sent the light, then *R* is "slower" relative to *T*. It was alleged that while the light reaching *R* is redshifted, the time dilation blueshifts the light back to its original frequency, thus "proving" that the clocks are synchronous and that there is no energy differential

between them induced by the acceleration according to the principles of relativity.[102] The naïve author of this argument failed to make a distinction between observations and conclusions that can be made from the perspective of an inertial observer, who is entitled to invoke special relativity, and the perspective of an accelerated observer inside the rocket, who is not entitled to do so. An observer inside the accelerating rocket cannot claim as alleged that clock *R* is slower than clock *T* due to a relative velocity, for no such velocity exists in the accelerated reference frame. Moreover, it is this velocity for the inertial observer in the context of special relativity that is the cause of the quantifiable transverse redshift.

For the inertial observer, the existence of the accelerating rocket *per se* is irrelevant. The only relevant observational fact is that a pulse of light expanding as a spherical wavefront at speed *c* is transmitted from clock T_1 (the first event) and received at a later time by clock R_2 (the second event), which is moving at a velocity Δv relative to T_1. Invoking special relativity, the inertial observer concludes that the light arriving at R_2 is redshifted as compared to the emission frequency (f_T) sourced at T_1 according to Eq. (64).

$$f_R = \frac{f_T\sqrt{1-\dfrac{\Delta v^2}{c^2}}}{\left(1+\dfrac{\Delta v\cos\theta}{c}\right)} \tag{64}$$

Let us assume a clock separation of 1 kilometer (the gedanken experiment allows for a very large rocket) so the light travel time is as much as ~3.34 microseconds. Assuming the rocket accelerates at one Earth gravity, the distance the rocket travels in this time is about 5.5×10^{-11} meter. Then the angle θ in Eq. (64) differs from a right angle by just ~3 parts in 10^{14}, so $\cos(\theta)$ is effectively zero. Then Eq. (64) reduces to the relativistic transverse Doppler formula as similarly referenced in Fig. (44).

$$f_R = f_T\sqrt{1-\frac{\Delta v^2}{c^2}} \tag{65}$$

With negligible error commensurate with the typically vanishingly small magnitude of $\cos(\theta)$, the change in velocity of the rocket (Δv) is its acceleration (g) multiplied by time, which is the lateral distance between the clocks (d) divided by the speed of light (c). Substituting for Δv in Eq. (65) yields a functional but naïve form of the transverse gravitational redshift formula derived from inertial acceleration.

$$f_R = f_T\sqrt{1-\frac{g^2d^2}{c^4}} \tag{66}$$

Based on first principles, an external inertial observer calculates this redshift between the clocks inside the rocket with good accuracy. From the inertial point of view, it is simple special relativity; the only thing that has any relevance in the matter is the relative velocity between the receiving clock *R* and the transmitting clock *T* and there is no physical phenomenon that can be invoked to 'neutralize' the effect.

Consider now the perspective of an observer traveling with a clock inside the accelerating rocket, which receives the regularly pulsed light signals from the other clock per Fig. (44). There is no relative motion between the two clocks in this reference frame. Can this observer, who makes actual measurements, claim some principle or effect that invalidates the theoretical calculation of transverse redshift made by the inertial observer? Similarly, can the accelerated observer claim that the pulse reception rate according to ideal clocks employing the same time unit is *identical* to the transmission rate even though the path length of light transmission between the clocks is increasing over time according to the inertial observer? Following a thoughtful and careful analysis, it must be concluded that the inertially accelerated observer must measure the effect quantified by Eq. (66) in accord with first principles.

An imagined theoretical problem concerning *TGR* that typically comes to mind is energy conservation. It would naïvely appear that the *TGR* phenomenon is inconsistent with energy conservation, yet this is an impossibility, for energy conservation is an inviolate first principle. — Upon careful consideration, the

apparent violation of energy conservation rests on nothing more than the "common sense" idea that a level surface in an accelerated reference frame represents an equipotential surface. However, this is just an *a priori* assumption induced by common experience and invalid application of Newtonian mechanics where relativistic mechanics is required. The conventional Newtonian idea that a mechanically level surface represents an equipotential surface is not an inherent first principle any more than the Newtonian idea that all clocks record the same universal time. Modern physics allows that radiation energy can be absorbed by the gravitational field and indeed this is the case when one considers either the conventional Einstein redshift in the radial direction or *TGR*. Relativistic transverse gravitational redshift does not violate conservation of energy simply because it *cannot* do so. However, it *does* invalidate the long-held false assumption arising from Newtonian mechanics that a level surface in an accelerated reference frame represents an equipotential surface. This anachronistic definition is inconsistent with relativity.

Although it is associated with accelerated reference frames, transverse gravitational redshift rests on the principles of special relativity, so its theoretical foundation and empirically verifiable physical existence is unassailable. Any assertion on theoretical grounds that the effect does not exist is equivalent to the assertion that the speed of light pulses exchanged between the two clocks is not constant according to the inertial observer. This is tantamount to abandoning special relativity. Note that in the fraction under the radical in Eq. (66), the denominator (c^4) is on the order of 10^{34}. Assuming that g incurs comparatively little variation over a transverse signal path (e.g., within a few radii of an astrophysical source body) this means that the effect is negligibly small except for quite large values of d that one typically encounters with the signal paths of satellite and spacecraft telemetry, in addition to astrophysical radiation sources.

For Earth gravity ($g \approx 9.82\ m/s^2$) over a distance of 1 kilometer, the calculated magnitude of the effect is less than 1 part in 10^{26}. The Equivalence Principle implies that the identical effect must occur in a real gravitational field for clocks separated by a horizontal distance. Although the clocks are not moving relative to one another and are considered to be at the same gravitational potential according to Newton, light traveling between the clocks must incur a relativistic time dilation redshift. This is the equivalent phenomenon for a local gravitational field as the cosmological redshift. While the magnitude of the transverse gravitational redshift is too small to be observed in the laboratory, (e.g., LIGO), it is readily observable as an unmodeled modulation of satellite and spacecraft radio signals (e.g., Pioneer 10) and unmodeled redshifts of astrophysical objects (e.g., white dwarf stars). — The majority of observed photons emitted by a star have a vector component transverse to the star's gravitational field. It follows that the stronger the star's gravitational field, the greater will be the incurred relativistic transverse gravitational redshift, which is currently unmodeled. The Sun has a previously unexplained center-to-limb asymmetry with an unmodeled excess redshift of about 1 *km/s* (interpreted as a Doppler shift) at the limb.

> A wavelength shift ... has been measured in the wavelength region 1950-2000 Å. … After correction for the gravitational redshift and for all the known relative motions between sun and observer, the average residual redshift is 7 mÅ and could be from 5 to 12 mÅ for some individual reference lines. This corresponds in terms of velocity to an equivalent Doppler-Fizeau shift on the whole [solar] spectrum of about 1 km/s away from the observer [i.e., v ~ 0.007/1975 × *c*].[103]

> An unexplained center-to-limb variation [CLV] of solar wavelength has been known for 75 years. Many theories have been developed in order to explain its origin. Although recent studies reveal a large amount of new information on the solar chromosphere, such as asymmetries of lines and various mass motions in granules, which lead to wavelength shifts, no theory can consistently explain the observed center-to-limb variation. ...
>
> … the fact that there has been no contradicting observation of the red shift of the FeI lines, have firmly established that the wavelengths of the Fraunhofer lines in the solar spectrum are dependent upon distance from the solar limb. This CLV cannot be a consequence of [conventional] relativity, which predicts that all solar lines must be red shifted by a factor of 2.12 ´10^{-6} and hence should be independent of the position on the solar disk. … During those past years, observers hoped in vain to discover new facts, but the basic observations of the CLV have not changed in 70 years, as is stated by Howard et al. and Dravins…
>
> Observations have definitely determined that the red shift of the lines near the limb is larger than the value predicted by relativity and is accompanied by an asymmetry of the lines profiles.[104]

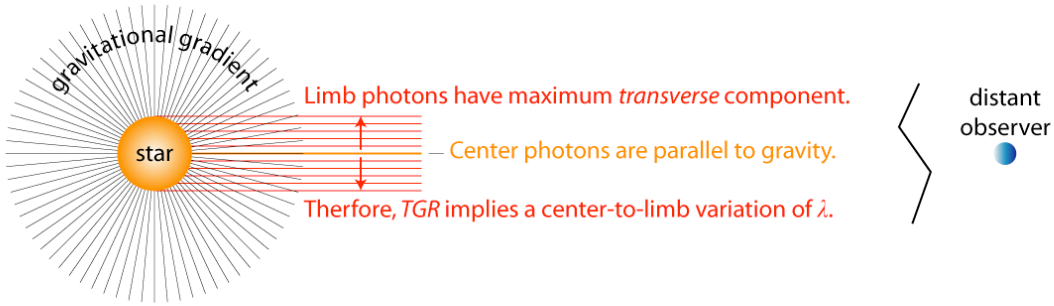


Figure 45 | *TGR* must cause a center-to-limb variation (CLV) in the wavelength of starlight. The Sun is close enough to resolve this variation. For all other stars, which are resolved as a single point of light, the majority of their light reaching Earth is sourced from regions near the limb. Consequently, the CLV induced by relativistic *TGR* will manifest as an observed *excess redshift* of starlight that increases with the surface gravity of the source star as well as *line broadening*.

Bright Class B stars (i.e., larger and more massive stars) with a stronger gravitational field than the Sun exhibit an excess redshift as first observed at San Jose's Lick Observatory in 1911.[105] Interpreted as a Doppler shift, this "K-Effect" makes the inference that larger, hotter stars have the improbable quality of a higher recession velocity from the Sun than smaller, cooler stars. As this is clearly not the case, relativistic transverse gravitational redshift is the likely explanation.

Due to their very significantly increased density and stronger gravitational field as compared to main sequence stars, the phenomenon of a radial differential in redshift must be particularly pronounced for white dwarf stars. The observed excess redshift of the observed point source of starlight could be conventionally interpreted as a familiar Einstein gravitational redshift; however, the relativistic mass commensurate with this interpretation of the observed redshift will imply a mass that is far too large for such a star according to astrophysical considerations.

> It is remarkable that the "relativistic" masses of the white dwarf stars, which one obtains by reduction of the observed redshifts, are (on the average, with large scatter) significantly larger than the "astrophysical" ones… Various attempts to explain this discrepancy have been made in the past, e.g., by asymmetry-induced shifts due to slope of the continuum (Schulz 1977) but this problem still is not solved (see also the review by Weidemann 1979). In velocity units the systematic excess of the observed redshift amounts to 10–15 $km\ s^{-1}$ (Shipman and Sass 1980; Shipman 1986) above "residual" redshift (i.e., redshift free of all kinematic effects).[106]

There are numerous other examples of observed phenomena that are almost certainly caused by relativistic transverse gravitational redshift. These include observations of anomalous redshift just prior to occultation of light from astrophysical sources or spacecraft radio telemetry, ubiquitous redshifts of galactic companions, geographic pulsar population statistics, asymmetry of spiral galaxy rotation curves, the Venus "black drop" effect, unlikely geodesy measurement peculiarities based on interpretations of incorrectly modeled satellite data and the apparent inherent asynchrony of geographically distributed atomic clocks. As *TGR* was not a previously known and modeled effect, most of these phenomena have been previously ignored, left open to question or have been attributed to unlikely other causes.

The *TGR* phenomenon involves an apparent paradox that warrants discussion. — Let there be two ideal synchronized clocks A and B in immediate proximity on an ideal motionless planetary geoid correlated with a static symmetric gravitational field. Consequently, no Sagnac or latitude effect exists. Let us now slowly move the clocks apart at the same speed to a distance d on the geoid so that they are subject to a relativistic transverse gravitational redshift. It follows that over an arbitrary period of time a symmetric time difference will accumulate between the clocks; according to clock A, it is clock B that has fallen behind by Δt seconds and according to clock B it is clock A that has fallen behind by Δt seconds. Let us now slowly move the clocks together on the geoid at the same speed so that they are in immediate proximity and their respective time readings can be compared. What are the clock readings?[107]

To answer this question, let us first consider a similar thought experiment in the context of special relativity. We imagine two identical spacecraft, each having an identical ideal clock. The spacecraft are docked in empty space ideally free of local gravitational influence. After the clocks are synchronized, the spacecraft undock and identical guidance programs using distant quasars as navigation aids accelerate the spacecraft in opposite directions. After a brief initial acceleration period, the rocket engines are turned off and the spacecraft then coast away from each other at constant velocity. From the point of view of each on-board clock, the clock on the other spacecraft is falling behind (i.e., losing time) in proportion to the relative velocity according to special relativity. After an arbitrary interval, the process is symmetrically reversed in order to bring the two spacecraft back together again. Accordingly, the guidance programs twice briefly accelerate the respective spacecraft, first so that they reverse coarse and later so that they may re-dock after the return coast phase. Again, during the entire return coast phase, a symmetric relativistic time dilation applies to the clocks on the respective spacecraft. There is no question that observers on each spacecraft will have found the other spacecraft's clock to record time at a slower rate than the local clock during an arbitrarily large portion of the mission's duration. So, after the mission, what do we find now when we compare the clocks? Clearly, the two ideal clocks must read the same time, but how can this be if during the entire mission of arbitrary duration, each clock perceived the other clock to be falling behind? — The resolution of this apparent conundrum requires us to consider the transition periods. In the foregoing special relativity illustration, the clocks are accelerated relative to one another during these transition periods. However brief and seemingly innocuous, these transitions are what allow the time on the clocks to match up with one another so that no paradox exists in the final identical reading of the two reunited traveling clocks. The Equivalence Principle implies that the same is true for the foregoing example of symmetrically traveling clocks on an ideal geoid. If only one Earth clock moves, the familiar twin paradox applies; the changing *direction* of acceleration is the applicable asymmetry.

Let synchronized clocks *A* and *B* in Fig. (44) be initially located immediately adjacent to one another along the axis of symmetry. Subsequently, the clocks are slowly and symmetrically moved apart. As they are moved apart, the illustrated increasing propagation delay for light signals exchanged between the clocks is incurred. As judged by the measured arriving rate of light pulses sourced from the other clock, each clock will experience the relative rate of the other clock to decrease in proportion to the acceleration and the separation distance between the clocks. From the point of view of an inertial observer, there will be an increasing number of light pulses sourced by each clock 'chasing' the other clock, but which have not yet arrived. According to the perspective of an inertial observer, this is due to the observed accelerated motion of the destination clock relative to the point in space at which each distinct light pulse was sourced from the other clock. After an arbitrary period, the clocks are moved back together again symmetrically. From the perspective of the inertial observer, this motion of the clocks will increase the rate at which the train of light pulses chasing each clock intersects with that clock. It follows that the motion of putting the clocks back together will cause each clock to have received all of the light pulses sent by the other clock by the time of their meeting. Thus, during the unique period when the clocks are in motion towards one another, each clock will seem to effectively leap forward in time relative to the time recorded on the local clock so as to match it. When the clocks are compared after they are reunited, they will be found to be synchronous. Although they read the same time upon being reunited, this does not imply that the clocks were synchronous relative to one another when they were separated.

According to the Equivalence Principle, the identical effect must occur for ideal clocks that are subject to the acceleration of a gravitational field. Regardless of how counterintuitive this may seem, it is dictated by first principles. Flawed arguments that may be raised in protest of this seemingly bizarre phenomenon, which implies that time does not behave in the 'appropriate' way that we may *feel* it should, are irrelevant. The distinction between physics and philosophy is the requirement that all claims in physics be proven by repeatable unequivocal experimental evidence, which overrules any seemingly correct intellectual or mathematical argument. The transverse gravitational redshift effect has been observed for decades in many different ways, but was not identified as such because it was incorrectly assumed that the Einstein field equations were faultless and properly interpreted. Moreover, in August 1929 it was the genius astrophysicist, Fritz Zwicky, who first proposed an essentially correct though naïve theoretical idea of the relativistic transverse gravitational redshift in the *Proceedings of the National Academy of Sciences* in an article entitled, "On the Red Shift of Spectral Lines Through Interstellar Space."

The Gravitational "Drag" of Light.—According to the relativity theory, a light quantum $h\nu$ has an inertial and a gravitational mass $h\nu/c^2$. It should be expected, therefore, that a quantum $h\nu$ passing a mass will not only be deflected but it will also transfer momentum and energy to the mass M and make it recoil. During this process, the light quantum will change its energy and, therefore, its frequency. It is hardly possible to give a completely satisfactory theory of this gravitational analogue of the Compton effect, without making use of the general theory of relativity. But a rough idea of the nature and the magnitude of the effect may be obtained...[108]

18. SELECTED HISTORICAL EMPIRICAL EVIDENCE OF *TGR*

A 1968 article in *Science* entitled "The Effect of Mass on Frequency" reported that radiation passing adjacent to the Sun experienced an unmodeled redshift and that atomic clocks on Earth exhibit an unmodeled time dilation related to great arc distance.[109] A prior article reported the following.

> The 21-centimeter absorption line from the direction of Taurus A was used for detection of a shift in frequency when the source passed near Sun. A possible decrease in frequency of 150 cycles per second was detected, which cannot be caused by general relativity or by the plasma around Sun. …
>
> In conclusion, a possible decrease in frequency of the 21-cm line was observed, with an indicated dependence of $1/r^2$. This decrease could be of great significance, as it indicates a red shift for waves passing near a mass, but a higher degree of statistical confirmation is needed.[110]

Peers with a stake in the status quo made other measurements and reported that the prior observations were inaccurate, rather than being indicative of a possible insufficiency in the conventional understanding of relativistic gravitational phenomena.[111] Notwithstanding, in the early 1970s, additional corroborating observational claims of a transverse gravitational redshift phenomenon appeared in the literature.

In, May 1974 Chastel and Heyvaerts of the Observatoire de Paris reported the following in *Nature* in reference to an unexplained anomalous observation of a redshift of Pioneer-6 telemetry discussed five years earlier in *Science*.[112]

> ATTENTION has been drawn recently to unexplained perturbations in the telemetry signal of Pioneer 6 (2,300 MHz) during solar occultation. The results shown in Fig. 1 present the following odd features:
>
> (1) An anomalous redshift is added to a normal linear redshift due to the spacecraft oscillator. This residual redshift which is symmetrical with respect to the center of the Sun is on the order of $z = 5.18^{-8}$ at four solar radii.
>
> (2) The bandwidth increases sharply when the telemetry signal grazes the Sun.
>
> (3) There are some extremely sharp pulses in the bandwidth. In Fig. 2 we show that these pulses are clearly associated with a sharp increase of the redshift…
>
> The existence of the redshift is particularly puzzling because it cannot be attributed to gravitational effects nor to the usual Doppler effect.[113]

Following are excerpts from a related 1974 paper by Merat *et al*. of the Laboratoire de Physique Théorique at Institut Henri Poincaré and Institut d'Astrophysique de Paris.

> An analysis of Goldstein's observations shows an anomalous redshift of the central frequency of the 2292 MHz band emitted by Pioneer-6 during its occultation by the sun. This shift, symmetrical with respect to the sun's center, does not correspond to any presently known physical effect. …
>
> In recent years an increasing number of observations (e.g. Arp, 1971; Pecker et al., 1972; Burbidge, 1973; de Vaucouleurs, 1972; Jaakkola, 1971; Tifft, 1972 and 1973; and others) suggest the existence of a new source of redshift distinct from Doppler-shift and the gravitational shift predicted by Einstein. To observe it, it is tempting to utilize the occultation of distant sources by the sun. Indeed, (neglecting, as we shall see, a small relativistic correction) associated shifts depend theoretically only upon the difference of gravitational potential between the source and the observer and upon their relative motion and can be computed accurately. Any supplemental shift (if definitely established) can thus be considered as evidence for a new effect.[114]

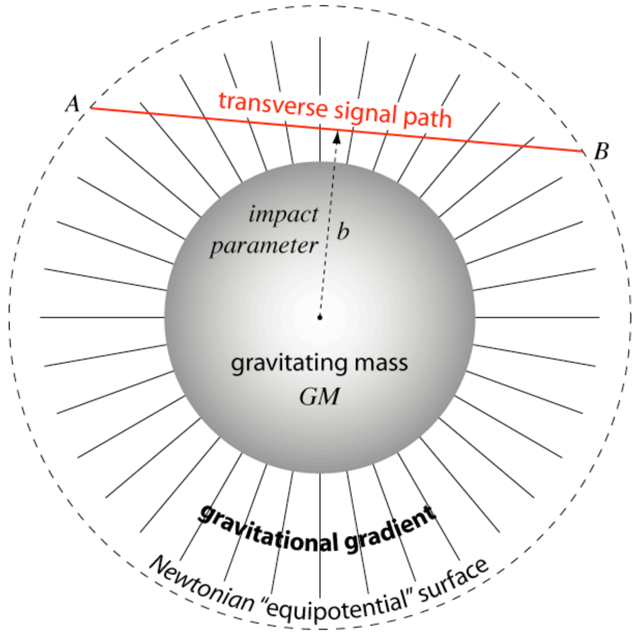


Figure 46 | *TGR* must cause a net redshift of the signal (i.e., energy loss) between *A* and *B*. It is currently erroneously assumed that there is no net energy loss of an electromagnetic signal associated with gravitational bending of light (i.e., a transverse path). *TGR* implies that an inbound signal at *A* emerges at *B* with a greater wavelength and that the magnitude of the frequency drop is inversely related to the impact parameter (*b*). There are numerous observed examples of this particular effect in the literature that are unexplained, "removed" or attributed to conventional causes.

Why were these and other empirical indications of an error in gravitational theory essentially ignored? Historically, significant investment in a particular paradigm by succeeding generations of academics has caused a resistance to change, even in the face of convincing empirical evidence supported by rational theory, which was discussed at length by Kuhn in *The Structure of Scientific Revolutions*. The Copernican revolution was primarily fought between Galileo and academic peers invested in Aristotelian cosmology. Galileo's famous 1615 letter to the Grand Duchess Christina of Tuscany, reveals that Church authorities were a political weapon successfully used by resentful academics.[115] Children routinely point out the obvious fact that Africa and South America "fit together," yet when Alfred Wegener proposed the theory of continental drift in 1912, it took the academic world over half a century to accept the new idea.[116] In a 2002 paper describing observed anomalies in the telemetry of the Pioneer-10 and Pioneer-11 spacecraft, the Pioneer Navigation Team described a common misstep in science.

> Procedures have been developed which attempt to excise corrupted data on the basis of objective criteria. There is always a temptation to eliminate data that is not well explained by existing models, to thereby "improve" the agreement between theory and experiment. Such an approach may, of course, eliminate the very data that would indicate deficiencies in the *a priori* model. This would preclude the discovery of improved models.[117]

A different but similar error is to acknowledge an empirical observation, but to attribute it to the wrong cause as a means of "solving" a problem rather than accepting ambiguity or ignorance. Moreover, there is a natural tendency to interpret anomalous data in the particular context of what is called for by the mission and what is familiar. For example, a team of planetary geologists is likely to interpret unexpected observation of the unmodeled *TGR* effect in radio science experiments as an indication of unlikely subsurface geologic mass density fluctuations or "gravity anomalies." A team of scientists probing a planet's atmosphere with the same technique is likely to interpret observed unexpected variations in spacecraft radio Doppler data as peculiar properties of a planet's atmosphere. So, in addition to ignoring anomalous data, it is also possible to incorrectly attribute it to a 'reasonable' cause. —

A lunar occultation occurs when the Moon passes in front of a star, temporarily blocking its light. Stellar occultation by the Moon has been used to identify binary stars since Antares was identified as a binary star system using this technique in 1819.[118] Light from a distant star that is occulted by the Moon exhibits Fresnel diffraction with the shape of the diffraction curve being dependent on the apparent angular size of the stellar disk and the wavelength of the light being observed.[119] Because the characteristic interference pattern caused by Fresnel diffraction is dependent on the wavelength, practical requirements imply that observations are conducted using astronomical bandpass filters at specific designated wavelengths. From red to violet, the visible spectrum or "V-band" spans wavelengths from about 7000Å down to 4000Å.

Because of the Moon's low mass (~1.2% of Earth) the magnitude of the transverse gravitational redshift phenomenon portrayed in Fig. (46) can be expected to be considerably smaller for the Moon than for planets or larger moons. When starlight just grazes the lunar limb, as occurs during lunar occultation of stars, the effect will be maximized and can be expected to manifest as a measurable redshift transition for immersion events (*b* decreasing) and a blueshift transition (removal of initial *TGR*) when a star emerges from behind the Moon (*b* increasing). *TGR* distinguishes itself from various other possible causes of signal frequency modulation in that it operates identically, rather than differently, at all wavelengths. It is likely that the following three occurrences of similar anomalous behavior at three different wavelengths (7×10^{-5}, 4.5×10^{-5} and 3.8×10^{-4} *cm*) during lunar occultation events are observations of the relativistic transverse gravitational redshift effect. Due to the *TGR* effect at the limb, the source starlight passing through a particular filter would not be a consistent wavelength over the sample time.

> Even here, the detection is not without some complications. …there is a strong distortion in the fringe pattern some 250 ms after the geometrical reappearance of the primary. We suggest that this is due to a limb distortion, since scintillation will produce deviations from the predicted signal, such as seen later in the tracings, that are strongly correlated in different wavelengths. … A boulder 10-20 m high could cause such a distortion. Note, particularly in the red channel, that the original fringe rate is recovered 50 ms further on.[120] [description of Fig. (47) *left*]

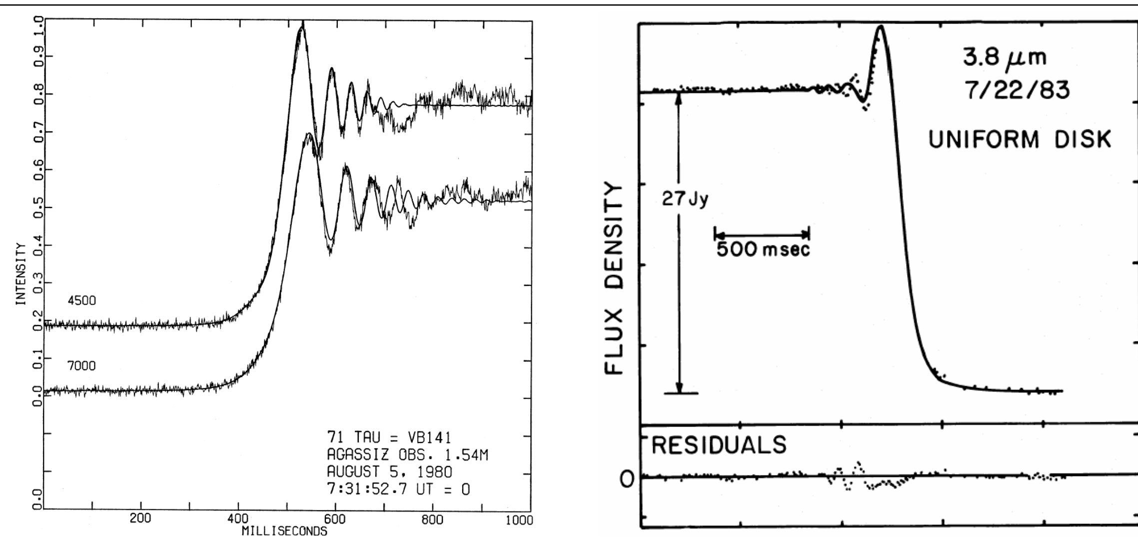


Figure 47 | Observed unmodeled behavior of Fresnel diffraction during lunar occultation.
The cause of the 1980 anomaly (left) was tentatively attributed to a boulder. Similar behavior for another observation at a much smaller wavelength in 1983 (right) implies that neither anomaly can be attributed to an obstruction. As the Moon has no atmosphere, the only remaining possibility is that the distortion is caused by a frequency modulation at the lunar limb.

Left: Deane M. Peterson *et al*., "Lunar Occultations of the Hyades. II. August 1980," *Astronom. J.* **86**, 1090 (1981), Figure 1a. © 1981, The American Astronomical Society.

Right: Michal Simon *et al*., "Lunar Occultation Observations of M8E-IR," *Astrophys. J.* **298**, 328 (1985), Figure 3a. © 1985, The American Astronomical Society.

Radio science experiments typically employ very precise measurement of radio Doppler and ranging data from distant spacecraft. Sophisticated celestial mechanics software provides comprehensive analysis of all of the forces acting on the spacecraft and perturbing effects on the signal. A "residual" refers to the difference between a precisely calculated modeled value according to all of the known laws of physics and the observed value. Thus, if both the model of the observed phenomenon and the data acquisition technique are accurate, the residuals are expected to be zero or reflect Gaussian noise.

The NASA/JPL *Galileo* spacecraft was launched on 18 October 1989, destined for Jupiter, the fifth and largest of the Solar System's planets, on what was to become a 14-year mission.[121] The mission was a remarkable success in spite of the unfortunate deployment failure of the spacecraft's high-gain antenna.[122] Precision radio Doppler telemetry was acquired during occultation by Jupiter and during flybys of the Galilean moons: Io, Europa, Ganymede and Calisto. The results of some of these experiments appear to reveal the *TGR* effect whereby the Doppler signal incurs an increasing unmodeled redshift (i.e., "drift") during the approach phase to occultation and an unmodeled blueshift after emerging from occultation. Earlier radio occultation experiments in 1979 using the Voyager-2 spacecraft at Jupiter seem to have also revealed the effect.[123] Heretofore, the observed effect was either treated as a nuisance and removed or conventional explanations were attributed to the anomalous phenomenon.

> On December 8, 1995, the Galileo spacecraft disappeared behind Jupiter for 3.7 hours. During the 6.2 hours centered on the occultation, the spacecraft LGA [low-gain antenna] radiated a coherent signal at a frequency of 2.3 GHz derived from an ultrastable quartz oscillator (USO) on board. This signal was tracked by the 70-m diameter antenna of NASA's Deep Space Network near Madrid, Spain. …
>
> We extracted the time history of signal frequency through Fourier analysis of these data. We then obtained residual frequencies by subtracting the frequency variation that would have been observed in the absence of an atmosphere/ionosphere on Jupiter. These residual frequencies exhibit a small long-term drift, of order 10^{-4} Hz sec^{-1}, *presumably* from instability of the USO and refraction in the interplanetary plasma and Earth's ionosphere. <u>We removed this drift</u> through use of a simple function fitted to the frequency residuals over a baseline interval well above Jupiter's ionosphere. Separate corrections were applied at ingress and egress.[124]

Following is an excerpt from a similar second report.

> A search for an atmosphere on Europa was carried out when Galileo was occulted by Europa three times. … For a few minutes before and after the occultations, the S band (2.295 GHz, or about 13 cm wavelength) radio signal from Galileo traversed regions above Europa's surface in which one could observe the effects of refraction by an atmosphere, or more precisely, an ionosphere (a layer of ions and electrons produced in tenuous regions of the atmosphere by photoionization and magnetospheric particle impact), should one exist on Europa. …
>
> Ideally, these residuals should have a zero baseline, which is the portion of the data that is away from the influence of possible ionospheric refraction effects. In reality, because of drift in the USO, effects of the long propagation path through the interplanetary medium, and imperfect knowledge of the frequency transmitted by Galileo and the spacecraft trajectory, this baseline has not only a non-zero mean but also a slope, which over periods of ten minutes can be approximated by linear frequency drift. <u>The bias and linear drift in the residuals were removed</u> by fitting of a straight line to the baseline data…[125]

One of the key scientific objectives of the *Galileo* mission was to "determine the gravitational and magnetic fields and dynamic properties of the Galilean satellites."[126] Ganymede is the largest satellite in the Solar System, having a 5,262 *km* diameter and a mass of 1.48×10^{23} *kg*, or about double that of the Earth's Moon. In the second *Galileo* flyby of Ganymede (G2) to an altitude of ~260 *km*, Doppler velocity residuals were observed that are consistent with *TGR*. The unexpected Doppler data was interpreted to indicate "surprising" (i.e., unlikely) geologic "mass anomalies." According to the non-standard JPL/DSN reversed sign convention, the graph in <u>Fig. (48)</u> shows a redshifting tendency to maximum reported anomalous Doppler redshift of about 1.5 *mm*/*s* about 1 minute following closest approach. Following this maximum is an immediate transition to a blueshifting tendency where the graph drops to its minimum point. Subsequently, there is a redshifting tendency transitioning to modeled behavior.

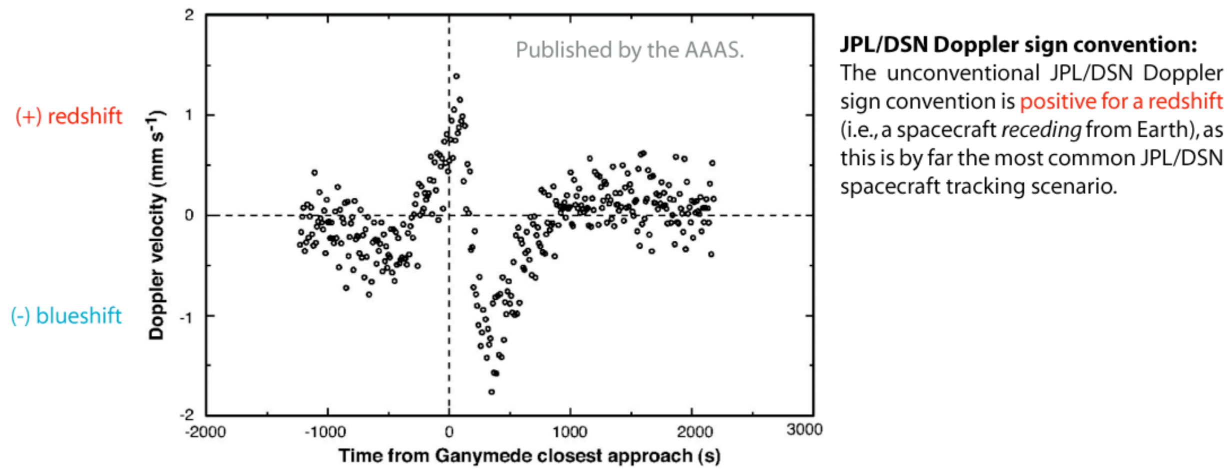


Figure 48 | DSN radio Doppler residuals from second flyby of Ganymede (G2). Figure 2 from John D. Anderson *et al*., "Discovery of Mass Anomalies on Ganymede," *Science* **305**, 989 (2004). The JPL/DSN (Deep Space Network) convention for Doppler frequency shift is *positive* for the most common case for JPL of a spacecraft *receding* from the tracking station (redshift), and negative for a spacecraft approaching the station (blueshift). This is the opposite of standard textbook convention.[127]

The residuals shown in Fig. (48) are after application of a fitting model to the raw Doppler data that includes Ganymede's mass (*GM*) and its second degree and order gravity field. The interpretation of this anomalous data initially published in 2004 was consistent with the designated mission.

> We present the discovery of mass anomalies on Ganymede, Jupiter's third and largest Galilean satellite. *This discovery is surprising for such a large icy satellite.* We used the radio Doppler data generated with the Galileo spacecraft during its second encounter with Ganymede on 6 September 1996 to model the mass anomalies. Two surface mass anomalies, one positive mass at high latitude and the other a negative mass at low latitude, can explain the data. *There are no obvious geological features that can be identified with the anomalies…*[128] (emphasis added)

A subsequent paper (2006) reported that *four* rather than just two different "mass anomalies," coincidentally lying just under or adjacent to the spacecraft ground track, were required to account for the unexpected Doppler data. Its abstract states: "Radio Doppler data, generated with NASA's *Galileo* spacecraft during its second encounter with Jupiter's moon Ganymede, are used to infer the locations and magnitudes of mass anomalies on Ganymede."[129] This specific interpretation of the data by a science team that included a majority whose primary expertise is in geophysics and planetary physics and whose pre-existing mission objective was to determine the gravitational properties of the Jovian satellites was almost inevitable.

There are actually two possible interpretations of the plotted Doppler residuals: unlikely significant asymmetries in the density of matter within Ganymede or a deficiency in the *a priori* model of how the Doppler telemetry behaves in a gravitational field. The idea that the anomalous Doppler data is indicative of an error in the relativistic gravitational model apparently did not occur to the G2 flyby science team. The spacecraft signal was never occulted by Ganymede, but the flyby certainly caused the telemetry signal to have a dynamic component transverse to the Jovian moon's gravitational gradient.

Note that the maximum anomalous redshift in the Doppler data occurs about 1–2 minutes after closest approach, followed by a rapid transition to an anomalous blueshift that subsequently dissipates. If the observed residuals are caused by *TGR* instead of the suspected unusual geologic asymmetries, the observed maximum shown in Fig. (48) after closest approach should correlate with a maximum transverse component of the signal path close to the surface. The subsequent transition to a dynamically decreasing value of the *TGR* effect would correlate to an anomalous blueshifting tendency that decreases as the spacecraft increases its range from Ganymede. This is exactly what we see in the data.

Spectroscopic analysis shows that spiral galaxies rotate in the plane of their disk. Bisected through their center, half of the disk exhibits a blueshift and the other half a redshift. One must expect an approximately symmetric self-gravitating object to exhibit highly symmetric rotation, particularly as the orbits of stars and clusters of stars in the disk are well understood to be elliptical with an aggregate circular motion. However, it is well known that these rotation curves exhibit a puzzling asymmetry and our Milky Way galaxy is no exception. The northern observation exhibits a rough radial symmetry with the southern observation but the former, which is in the direction of galactic rotation, is measured to be typically about 5 *km/s* faster than the latter.[130] While a number of radically different theories have been put forward to account for this anomaly, none are even remotely satisfying; they simply do not explain the observation.

> Asymmetry is often observed in rotation curves of spiral galaxies. Like the rotation curve, asymmetries indicate the forces and dynamics in a galaxy. Small deviations in the rotation curves of a few km s^{-1} are well known (Shane and Bieger-Smith 1966). Large deviations are less appreciated (Jog 2002) because the observational data are generally averaged. Hence, only highly asymmetric cases such as NGC 4321 (Knapen et al. 1993) and NGC 3031 (Rots 1975) are recognized. The rotation curves of all the nearby galaxies where the kinematics are studied have asymmetry such as NGC 0224 (Simien et al. 1978) and NGC 0598 (Colin and Athanassoula 1981). Asymmetry has also been reported in the inner parts of the optical disk (Sofue 1988). Rotation curve asymmetry appears to be the norm rather than the exception (Jog 2002). Weinberg (1995) and Jog (1997) proposed the implied mass asymmetry is due to a galaxy interaction. In this Paper, the rotation curve asymmetry from our viewpoint is related to the strength of the forces from neighboring galaxies.[131]

Due to the gravitating mass in the galaxy disk, *TGR* must cause an unmodeled increase in the redshift and a decrease in the blueshift, causing an asymmetry in the two distinct curves. Thus, *it must always be the blueshift that is observed to be asymmetrically less than the redshift*. This will be particularly prominent for the region adjacent to the massive central bulge. It is then obvious that a phenomenon that causes a general redshift is superimposed on a nearly radially symmetric relative velocity Doppler shift due to the circular rotation. The literature on rotation curve asymmetry has yet to make note of this observational detail. *TGR* implies that the redshifted side of a spiral galaxy rotation curve will always be observed to exhibit a "Doppler shift" relative to center that on average has a greater magnitude than the shift relative to center on the blueshifted side. This is unequivocal empirical evidence for *TGR*.

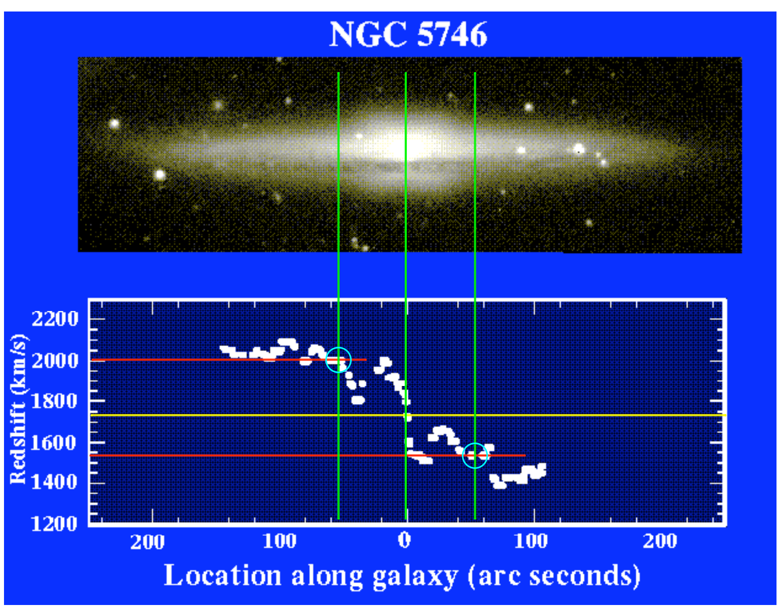


Figure 49 | Spiral galaxy rotation curve asymmetry favors the redshift adjacent to the bulge. The image is a red-light CCD frame taken by William C. Keel, University of Alabama, at the 42-inch Hall telescope of Lowell Observatory. The rotation curve was measured using the GoldCam CCD spectrometer on the 84-inch telescope at Kitt Peak. — Courtesy William C. Keel.

19. PREDICTIVE CALCULATION OF *TGR*

Einstein's synthesis of special relativity and accelerated frames of reference (i.e., general relativity) was a complicated mathematical approach that lacked an intuitive visual picture of the relevant principles. This was because he did not adequately understand Minkowski's geometrisation of time. Although GR yields accurate quantitative predictions for a subset of relativistic gravitational phenomena in the weak field, Einstein actually missed the key simplifying point (relativistic temporal geometry) in developing a general theory of relativity and produced an overly complicated and incomplete model. In particular, what is in hindsight an obvious phenomenon resulting from the principles of relativity was entirely missed.

The essential point encompassing all of relativity concerns *the geometry of time*. Quantitatively, this manifests as the effective geometric angle between the locally linear time coordinates (i.e., timelines) of distinct reference frames. — In Fig. (12) from *Section 6*, the relativistic time angle (ζ) was quantified in terms of the relative velocity in the context of special relativity. For an inertially accelerated rotating frame of reference as modeled by the rotating virtual 'disk' shown in Fig. (38), each point along a given radial coordinate, which is associated with a unique tangential velocity (v_r) at coordinate radius r, is also associated with a unique correlated relativistic 'time angle'.

$$\zeta_r = \sin^{-1}\frac{v_r}{c} \tag{67}$$

From trigonometric identities, it follows that

$$\sec\zeta_r \equiv \frac{1}{\sqrt{1-\sin^2\zeta_r}} = \frac{1}{\sqrt{1-\frac{v_r^2}{c^2}}} \tag{68}$$

From the perspective of the inertial observer at the center of the virtual disk ($v_r = 0$), the relativistic time dilation of eccentric (i.e., *accelerated*) ideal clocks on the disk may be parameterized accordingly. The variable t represents *coordinate time* (i.e., the proper time of the inertial frame).

$$\frac{dt}{d\tau_r} = \sec\zeta_r \tag{69}$$

The distinction between this equation and Eq. (6) referencing Fig. (12) is clear. Formerly, in the case of unaccelerated frames in the context of special relativity, the relativistic temporal relationship dependent on relative velocity was symmetric. In the case of the rotating disk, the inertial observer has a preferred frame of reference; among all observers at various points on the disk, the observer at the center uniquely experiences no acceleration. Relative to all other clocks on the disk, the clock recording *coordinate time* (t) there is a faster clock in an absolute sense. Therefore, the magnitude of the relativistic time angle is also absolute; per Eq. (67), ζ_r is exclusively zero at the origin, which represents inertial space, and in general ζ_r has a specific calculated value determined by the local characteristic tangential velocity (v_r).

Recall that by Eq. (46) and the Equivalence Principle, it was shown that the tangential velocity of any point p on the virtual rotating disk provides a direct analogy to the escape velocity measured at a point in a real gravitational field. Then the *gravitational* relativistic time angle (η), which is directly correlated to the related phenomena of gravitational time dilation and gravitational redshift is specified by

$$\eta \equiv \sin^{-1}\frac{v_{esc}}{c} = \sin^{-1}\sqrt{\frac{2GM}{rc^2}} \tag{70}$$

The gravitational relativistic time angle approaches zero ($\eta\rightarrow 0$) in the limit of arbitrarily large coordinate radius ($r\rightarrow\infty$) and its maximum value occurs at the surface of the source mass M. In this development we assume the same idealized static, symmetric gravitational field as was assumed by Karl Schwarzschild. This is a close approximation to actual gravitational fields associated with typical astrophysical bodies.

The fundamental conventional interpretation of general relativity is "space tells mass how to move and mass tells space how to curve." Previously, the nature of this "curvature" was a confused and inaccurate mathematical abstraction. Given the Schwarzschild assumptions, Eq. (70) simply and perfectly describes both the geometric and physical nature of that curvature as illustrated in Fig. (50). Upon approaching the vicinity of the source mass, "time becomes space"; *space curves in concert with the geometry of time*.

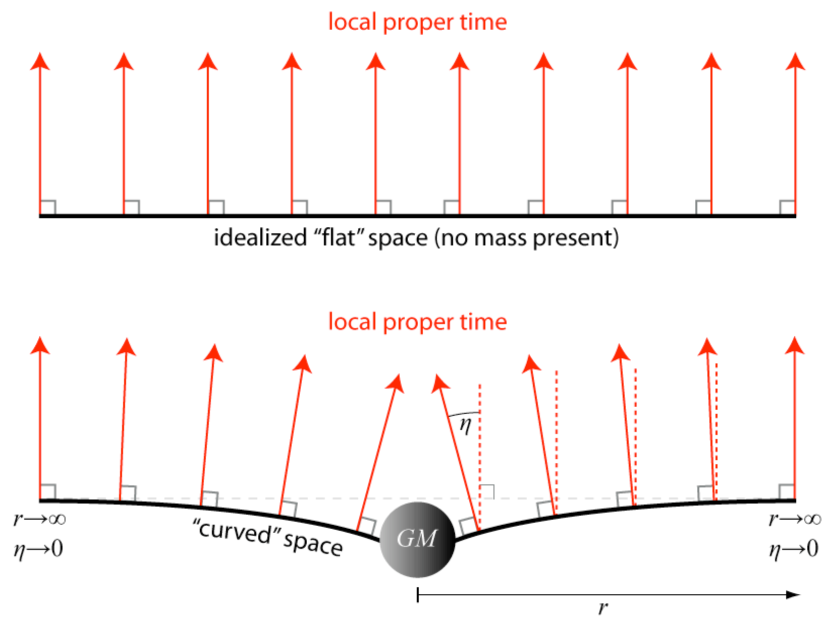


Figure 50 | Profile of Eq. (70) and an accurate depiction of "spacetime curvature." In this schematic, the third spatial dimension (z) is suppressed. The dark line represents a plane (e.g., x–y) as physically perceived by observers. The magnitude of η is shown greatly exaggerated; at the surface of the Sun, $\eta \approx 2.1\times10^{-3}$ radian and at the surface of the Earth, $\eta \approx 3.7\times10^{-5}$ radian (~0.002º).

The magnitude of the Einstein gravitational redshift, expressed geometrically [$f(\eta)$], is given by

$$z_{GR} = \sec\eta - 1 = \left(1 - \frac{2GM}{rc^2}\right)^{-\frac{1}{2}} - 1 \tag{71}$$

Due to the curvature of space, computation of the relativistic time angle between two points is indirect. Consequently, the gravitational time dilation between any two radial coordinates ($r_1 \to r_2$) is given by

$$\Delta z_{GR} = \sec\eta_2 - \sec\eta_1 \tag{72}$$

A negative result implies a redshift. — For example, for the average GPS satellite orbit altitude,

$$r_2 \approx 2.656\times10^7 m \quad \to \eta_2 \approx 1.828\times10^{-5} \tag{73}$$

For a ground station at sea level, the typical gravitational redshift is

$$r_1 \approx 6.371\times10^6 m \quad \to \eta_1 \approx 3.732\times10^{-5} \tag{74}$$

According to Eq. (72) and practical reality, the Einstein redshift independently causes a ground station clock to lose about 46 microseconds per day relative to a GPS satellite's on-board atomic clock.

$$\Delta t_{GR} = \Delta z_{GR}\left(8.64\times10^{10}\ \mu\text{sec/day}\right) = -45.7\ \mu\text{sec/day} \tag{75}$$

At this point we have done nothing new, other than to reify GR by introducing the idea that the Einstein redshift can be described in the context of temporal geometry. However, upon consideration of this more intuitive geometric conception of general relativity, it is apparent that local time coordinates at constant coordinate radius cannot be parallel. Moreover, the geometric variation of proper time with azimuth angle is understood to imply a relativistic time dilation. Symmetry considerations imply a relativistic transverse redshift between points on a chord at the same Newtonian gravitational potential (i.e., coordinate radius). Indeed, on the local scale of a gravitational field produced by a source mass, the gravitational transverse redshift is the identical phenomenon to the cosmological redshift. Both are correlated to relativistic temporal geometry (i.e., a change in the direction of time in spacetime between reference frames).

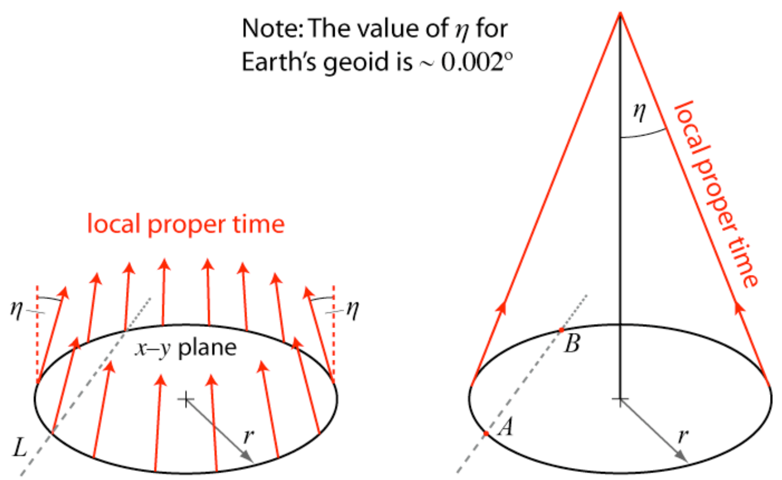


Figure 51 | Oblique view of Eq. (70). For the two points (A, B) at identical coordinate radius in an idealized static symmetric gravitational field, their respective proper time coordinates are not parallel. The geometry implies a symmetric relativistic time dilation (i.e., a transverse gravitational redshift). The temporal geometry of the idealized field corresponds to an infinite number of right circular cones with aperture $2\eta_r$ associated with each plane (e.g., x–y) taken through the centroid of the source mass.

Calculation of gravitational transverse redshift requires a line integral that sums the differential transverse component of the time angle change over a path L. Although the path L must actually be a high-eccentricity hyperbola per Fig. (41), for the purpose of practical calculation of the *TGR* effect for typical astrophysical objects, it is reasonable to assume that it is a straight line as shown in Fig. (52).

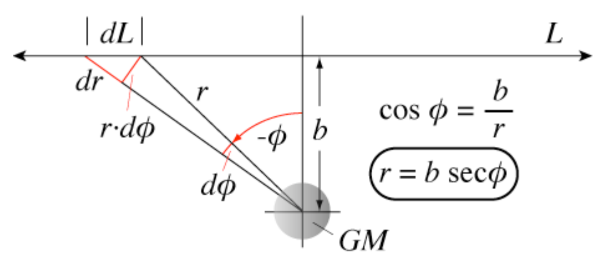


Figure 52 | Geometry of a linear transverse signal path. The coordinate radius may be expressed as a simple function of the impact parameter (b) and the polar angle (ϕ). The transverse component of the differential line element dL is simply ($r\ d\phi$). The angular change in the direction of time over dL (not shown) includes the change correlated to the radial Einstein redshift. In order to calculate the magnitude of the transverse redshift, it is necessary to isolate the angular displacement of the proper time vector correlated exclusively to the local transverse component of L. Integrating this differential between any two points yields the transverse redshift. This relationship between the radius (r) and the impact parameter (b) is also valid if the path (L) intersects with the body (i.e., a ground station).

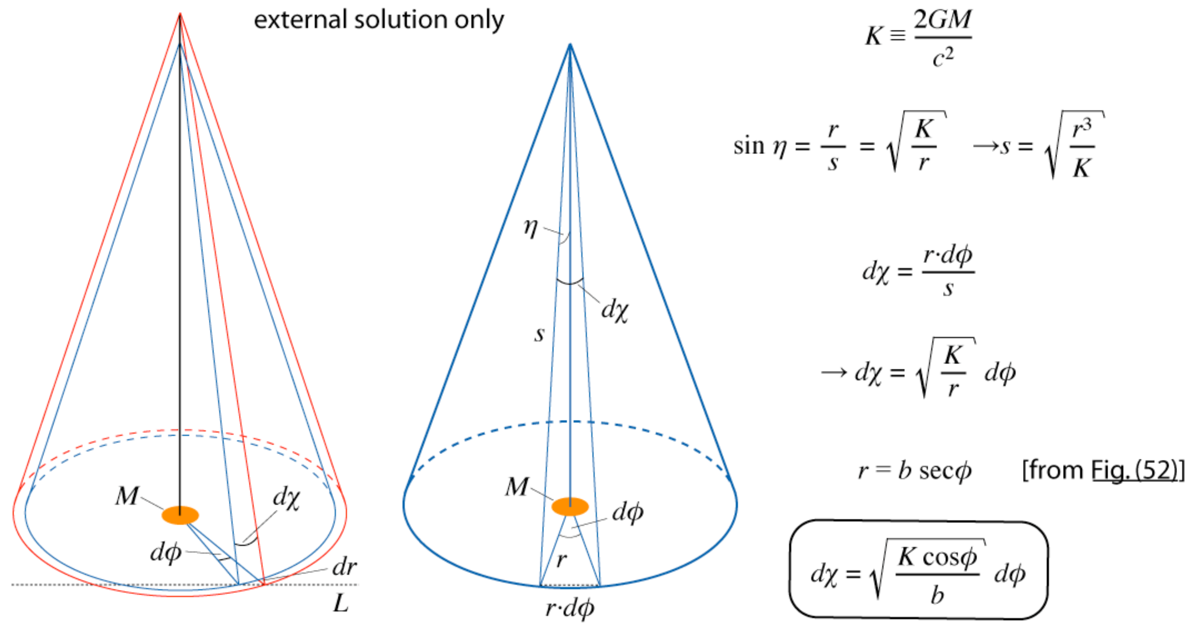


Figure 53 | The geometry of the differential relativistic time angle ($d\chi$). The left drawing shows that r is a function of ϕ. On the right, the *tangential* (transverse) differential component is isolated.

Integrating the circled geometric differential equation above yields the effective relativistic transverse time angle between two points in a gravitational field. E represents the elliptic integral of the second kind.

$$\chi = \int \sqrt{\frac{K\cos\phi}{b}}\, d\phi = \frac{2\sqrt{\frac{K\cos\phi}{b}}\; E\left(\frac{\phi}{2}|2\right)}{\sqrt{\cos\phi}} \qquad \left[K = \frac{2GM}{c^2}\right] \tag{76}$$

The predicted transverse gravitational redshift (z_χ), also expressed as a Doppler shift, is given by

$$z_\chi = \sec\chi - 1 \qquad cz_\chi \rightarrow \text{km/sec} \tag{77}$$

In the case of the observed and heretofore unexplained "limb effect" (excess redshift) of stars depicted in Fig. (45) as a result of *TGR*, the applicable limits of integration over the angle ϕ are zero, representing the limb of the star and *pi*/2, representing the observer at arbitrary distance (i.e., $r \rightarrow \infty$). A numerical evaluation of the integral at these boundaries using Mathematica yields

$$\texttt{N[Integrate[Sqrt[K / b * Cos[x]], \{x, 0, }\pi\texttt{ / 2\}]] = 1.19814}\sqrt{\frac{\texttt{K}}{\texttt{b}}} \tag{78}$$

Consequently, the value of χ for light originating at the solar limb is

$$\chi = 1.198\sqrt{\frac{2GM_\odot}{R_\odot c^2}} \approx 2.468 \times 10^{-3} \tag{79}$$

The calculated excess redshift at the solar limb due to *TGR*, expressed as an equivalent Doppler shift, is consistent with empirical observations of the unexplained center-to-limb variation of solar wavelength.

$$cz_\chi = \left(2.998 \times 10^5 \text{km/s}\right) \cdot \left[\sec\left(2.468 \times 10^{-3}\right) - 1\right] = 0.91 \text{ km/s} \tag{80}$$

The magnitude of the *TGR* effect at the limb of a star is consistently greater than the Einstein redshift. Fig. (54) graphs both independent redshift effects for main sequence stars as well as the combined sum yielding the observed total gravitational redshift at the limb. According to convention, the graphs assume a consistent mass-radius relation for these stars $R \propto M^{0.8}$, where both are expressed in solar units.[132]

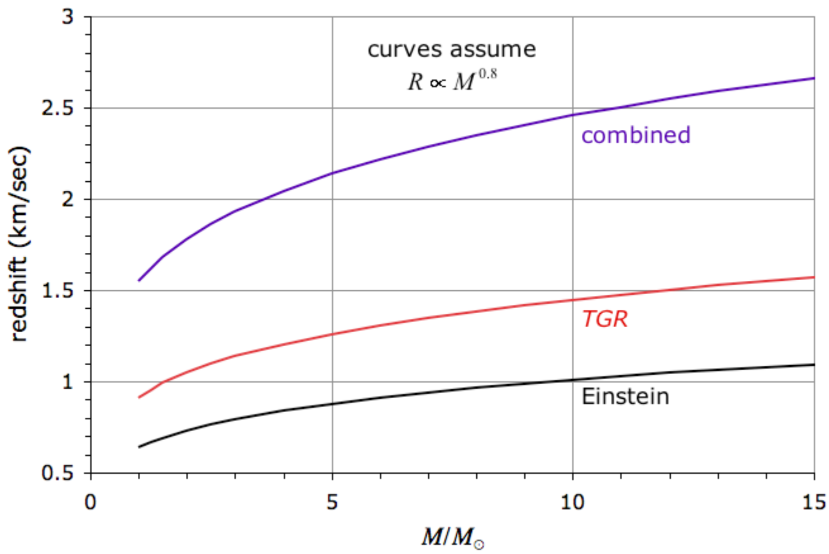


Figure 54 | Graph of Eq. (71) and Eq. (77) for ($R \propto M^{0.8}$) main sequence stars. The Einstein redshift (lower curve) occurs for all photons. The middle curve (*TGR*) is the maximum magnitude of the gravitational transverse redshift effect for photons sourced from the limb. Photons sourced from the stellar limb will exhibit a redshift that is the linear combination (top curve) of both the Einstein gravitational redshift and *TGR*. A frequency continuum exists between the bottom and top curves. This continuum corresponds to photons sourced from the center of the disk (no *TGR*) and those with increasing magnitude of *TGR* as the photon source point radial coordinate increases out to the limb.

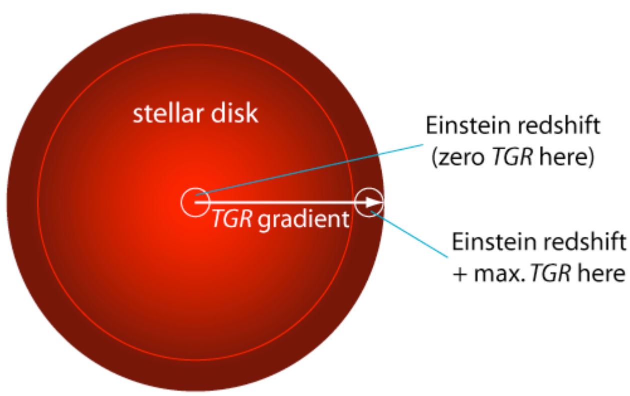


Figure 55 | Photon flux increases with the magnitude of *TGR*. Like the Sun, all stars present the observer with a 2-dimensional stellar disk. Obviously, the area of this disk within a differential ring at constant radius ($2\pi r \cdot \Delta r$) increases with the radius. The two white circles shown have the identical area so it is clear that substantially more photons are produced with a higher redshift due to *TGR*. As a continuum of observed photon frequencies is produced over the range of the *TGR* effect, spectroscopy will show line broadening of starlight with an inverse relationship between frequency and flux. This line broadening effect will be particularly conspicuous for white dwarf stars, which have a much higher mass to radius ratio than main sequence stars.

Development of the astrophysical theory of white dwarf stars, in particular the mass-radius relation, was strongly influenced by measurement of their redshifts, inferred to yield their mass according to the Einstein redshift upon removal of the estimated Doppler component, determined from spectroscopic measurements of neighboring main sequence stars.

> The gravitational redshift is one of Einstein's original tests of the theory of general relativity, and the first confirmatory measurements were of the white dwarf star Sirius B (Adams 1925). Assuming that general relativity has passed this test, one can now use the redshift measurement to determine the ratio of mass to radius of a white dwarf, provided that the systemic radial velocity of the star is known—for those in binary systems or star clusters. One can generally also assume that the intrinsic mass-radius relation for white dwarfs of a given composition is known fairly accurately—from detailed evolutionary calculations which account for a swelling of the white dwarf radius due to finite temperature effects (Wood 1990). One can then determine both the mass and the radius of a given star.[133]

> Since the appearance of general relativity theory, it has been a challenge to astrophysicists to determine the predicted gravitational redshift in stars, and white dwarfs have been primary candidates due to their small radii and comparatively large masses. Adams (1925) was the first to attempt the extremely difficult observation for Sirius B—difficult due to the large amount of scattered light from the much brighter Sirius A. Although in 1925 the observed value was regarded as a confirmation of general relativity as well as the theory of white dwarfs, we know today that the result was grossly in error.[134]

It is currently acknowledged that the masses of white dwarfs according to their (assumed) Einstein gravitational redshift appear significantly larger than should be the case. There has been no prior explanation for this empirical anomaly. Confirmation of the predictive accuracy of Eq. (77) will require a reevaluation of prior assumptions. *TGR* implies that the observed redshift of a white dwarf star excluding Doppler component correlates to a significantly smaller stellar mass than was previously assumed.

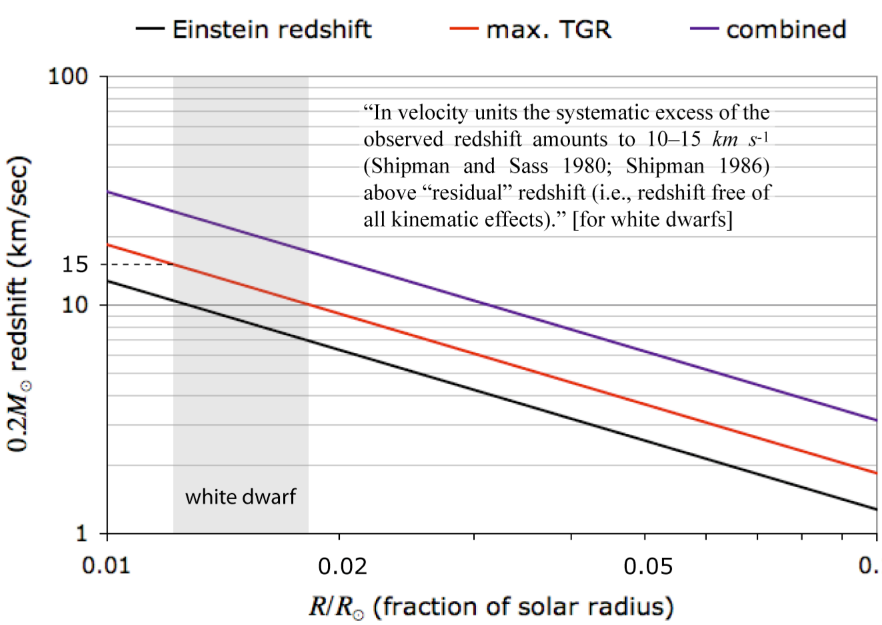


Figure 56 | Graph of Eq. (71) and Eq. (77) relevant to compact stars. These curves assume a compact mass of $0.2M_\odot$ (1/5th of a solar mass) with varying density according to the unknown radius. The graph implies that *TGR* causes a significant portion of the observed line broadening of white dwarf starlight. The radius of a white dwarf star of this mass is currently assumed to be about $0.02R_\odot$. Recognition of *TGR* is likely to reduce this estimate to within the shaded range shown in the graph.

20. A PREDICTION FOR THE 2009 NASA LRO MISSION

As the first spacecraft of the NASA Robotic Lunar Exploration Program, the Lunar Reconnaissance Orbiter (LRO) is currently scheduled for launch on 24 April 2009.[135] The LRO spacecraft includes a laser ranging (LR) system, which will assist conventional S-band radio tracking in making precise one-way range measurements from Earth to the spacecraft. This is intended to yield LRO orbital position measurements having sub-meter resolution. The LRO is to be inserted into a nearly circular lunar polar orbit with an altitude of ~50 *km* and is expected to gather data for a period of about one year. Because the Moon has no atmosphere, S-band radio Doppler residuals that are inconsistent with laser ranging due to relativistic transverse gravitational redshift cannot be mistakenly attributed to atmospheric effects.

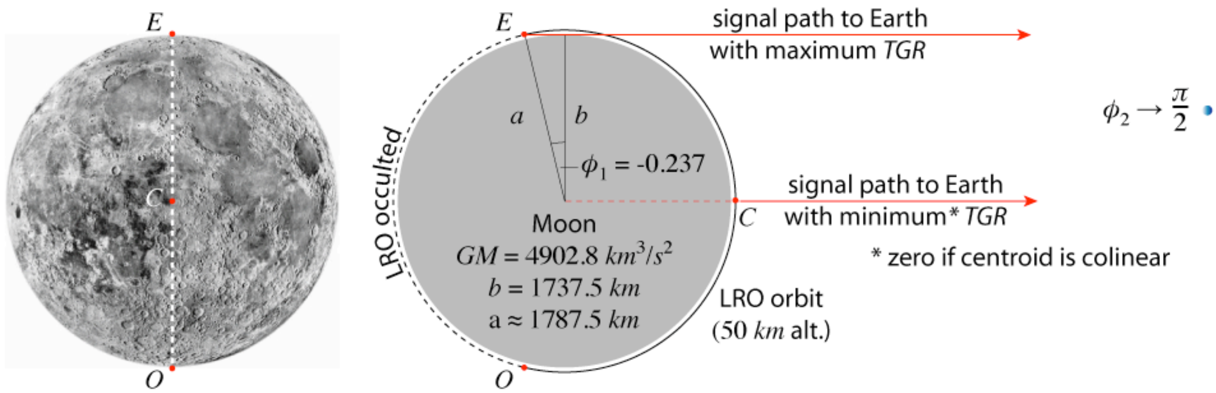


Figure 57 | Geometry of LRO orbit yielding maximum *TGR* amplitude. The maximum *TGR* effect occurs twice per orbit: just prior to lunar occultation of the spacecraft and at emergence from occultation. The lunar *TGR* effect is zero for the special case in which the extended virtual signal path line between the LRO and the ground station intersects the lunar centroid. An orbit observed to pass through this point (i.e., directly between the center of the moon and the observer) yields a sinusoidal *TGR* signal modulation with maximum amplitude. Typically, the amplitude of the sinusoid will be less, because the minimum observed *TGR* will generally not be zero.

The following three equations calculate the maximum dynamical amplitude of the *TGR* modulation on navigation signals, which occurs when the signal path is very nearly in the LRO orbit plane as depicted in Fig. (57). At a range of about 400,000 *km*, the Earth station is effectively at infinity, so the integration extends to the limiting azimuth angle of *pi*/2. Note that the initial negative angle (ϕ_1) corresponds to a location beyond where the signal path is tangent to the lunar limb (i.e., $\phi = 0$).

$$\mathtt{N}\left[\mathtt{Integrate}\left[\mathtt{Sqrt}\left[\mathtt{K/b*Cos}[\mathtt{x}]\right], \{\mathtt{x}, -0.237, \pi/2\}\right]\right] = 1.43411\sqrt{\frac{\mathtt{K}}{\mathtt{b}}} \tag{81}$$

Consequently, the value of χ corresponding to maximum *TGR* effect for the LRO is

$$\chi = 1.434\sqrt{\frac{2GM}{bc^2}} \approx 1.136\times10^{-5} \tag{82}$$

The calculated maximum amplitude of the LRO *TGR* effect expressed as an equivalent Doppler shift is

$$cz_\chi = \left(2.998\times10^{10}\,\text{cm/s}\right)\cdot\left[\sec\left(1.136\times10^{-5}\right)-1\right] = 1.9\ \text{cm/s} \tag{83}$$

When the LRO orbit plane is very nearly perpendicular to the signal path, so that the Earth station perceives the orbit as a complete face-on circle, the range of the LRO is essentially the same as the range of the Moon's orbiting centroid. In this case, the *TGR* 'limb effect', which is correlated to the orbital radius

of the spacecraft rather than the lunar radius, will be very nearly constant. According to the following two equations, radio Doppler measurements will incorporate an excess redshift of about 1.3 *cm*/*sec*.

$$\chi = 1.198\sqrt{\frac{2GM}{ac^2}} \approx 9.359\times10^{-6} \tag{84}$$

$$cz_\chi = \left(2.998\times10^{10}\,\text{cm/s}\right)\cdot\left[\sec\left(9.359\times10^{-6}\right)-1\right] = 1.3\ \text{cm/s} \tag{85}$$

The maximum observable amplitude of *TGR* variation corresponds to the orbit of minimum visibility time, for which the LRO orbit passes through the center of the lunar disk as viewed from Earth. Corresponding to the orbit shown in Fig. (57), Fig. (58) graphs this complete range of the *TGR* effect as a sinusoidal function of time between emergence of the spacecraft from occultation at *E*, passage over the observed center of the lunar disk at *C* and subsequent occultation at *O* over about 65 minutes.

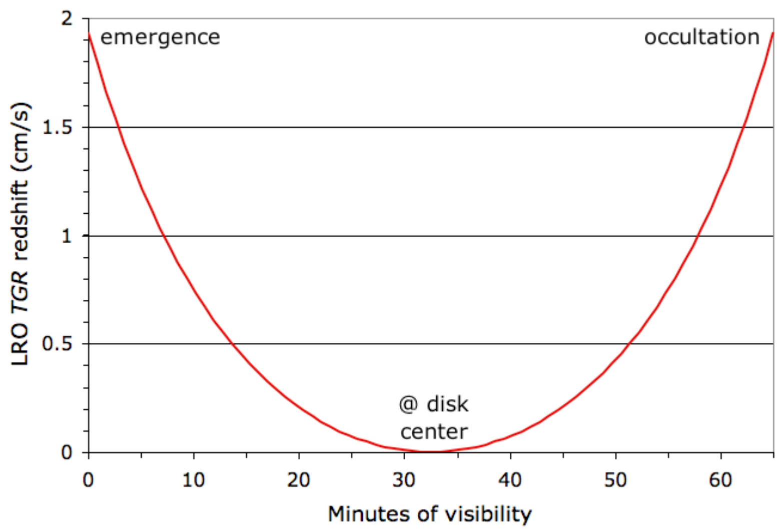


Figure 58 | Prediction of maximum amplitude lunar *TGR* effect on LRO radio Doppler data. The LRO is assumed to be in a circular orbit with a period of approximately 1^h53^m. The graph applies to a particular orbit for which the LRO orbit appears to pass over the center of the lunar disk as seen from Earth, about 32.5 minutes after emerging from behind the Moon and the same amount of time before subsequent occultation. More generally, the LRO orbit plane will be skew to the signal path. Consequently, the visibility time will be greater and the amplitude of the sinusoidal modulation will be smaller because the *TGR* will not drop to zero. The superimposed terrestrial *TGR* effect on measurements of the lunar effect can be minimized if they are made when the Moon is near zenith.

21. THE EFFECT OF *TGR* ON GPS SIGNALS

A constellation of 24 operational Global Positioning System (GPS) satellites and several immediately available standby replacements is managed by the U.S. Department of Defense. Each GPS satellite or "SV" (space vehicle) orbits the Earth in a nearly circular orbit (eccentricity typically less than 1%) at an altitude of 20,189 *km*; the average semi-major axis (a_{SV}) is 26,560.0 *km*. This orbital radius produces an orbital period of one half of a sidereal day (~11^h58^m), which allows the satellites to very nearly repeat the identical ground track every two orbital revolutions. There are six orbital planes spaced 60° apart and inclined from 51°–57° from the equatorial plane so that the system has optimal real-time global coverage. Each satellite carries four atomic time references (two cesium beam clocks and two rubidium clocks) and continuously transmits time and location on two frequencies. Only one of the atomic clocks is referenced during operation. The second frequency (L2) is used primarily to assist in the measurement of frequency-

dependent signal delays caused by Earth's ionosphere and troposphere. Access to the signals on the L2 carrier for precise positioning service is generally restricted to the military.

Although it is technically complex and four visible satellites are normally required for a fix, the GPS operates according to the simple geometric principle of triangulation. If the radial distances to three distinct coordinate reference points (i.e., GPS satellites) is known to some precision, the intersection of those radials yields neighborhoods of two points in space, one of which can be immediately rejected as not being a reasonable location for a GPS user. An orbiting GPS SV can function as a reliable spatial reference coordinate if all of the following three criteria are met: (1) its ephemeris is known (2) the time at which it transmitted a ranging signal is known (3) the speed and travel time of the signal are known. Consequently, the precision of coordinates determined by GPS is dependent on the precision with which *time* as recorded by clocks in relative motion and at different altitudes is both modeled and measured.

It should be clear that the following calculations are idealized as they do not take into consideration actual ephemeris variations and other factors that affect the real-world magnitudes. — A GPS SV orbits at high speed (~3874 *m*/*s*) so special relativity must be taken into consideration. Ignoring the variable relative velocity component produced by Earth's rotation, an ideal ground station clock appears to *gain* about 7.2 microseconds per day relative to an ideal on-board GPS SV clock.

$$v_{SV} = \sqrt{\frac{GM_{\oplus}}{a_{SV}}} \approx 3874 \text{ m/s} \tag{86}$$

$$z_{SR} = \gamma - 1 = \frac{1}{\sqrt{1 - \frac{v_{SV}^2}{c^2}}} - 1 = 8.349 \times 10^{-11} \tag{87}$$

$$\Delta t_{SR} = z_{SR}\left(8.64 \times 10^{10} \ \mu\text{sec/day}\right) \approx 7.213 \ \mu\text{sec/day} \tag{88}$$

To reiterate, the Einstein redshift causes an ideal ground station clock at sea level to *lose* nearly 46 microseconds per day relative to a GPS satellite's on-board ideal clock. Here, the mean Earth radius ($R_{\oplus}$) is 6371 *km* and the value of $GM_{\oplus}$ is 398600.4418 km^3/s^2.

$$\Delta z_{GR} = \left(1 - \frac{2GM_{\oplus}}{a_{SV}c^2}\right)^{-\frac{1}{2}} - \left(1 - \frac{2GM_{\oplus}}{R_{\oplus}c^2}\right)^{-\frac{1}{2}} = -5.291 \times 10^{-10} \tag{89}$$

$$\Delta t_{GR} = \Delta z_{GR}\left(8.64 \times 10^{10} \mu\text{sec/day}\right) = -45.718 \ \mu\text{sec/day} \tag{90}$$

Combining the two relativistic temporal effects ($\Delta t_{SR} + \Delta t_{GR}$) implies that an ideal ground clock loses about 38.505 microseconds per day relative to an ideal clock orbiting at GPS SV altitude. In order to account for this rate difference, an artificial frequency offset is applied to GPS clocks prior to launch. While ground clocks operate at a fundamental frequency of 10.23 MHz, GPS SV clocks are factory adjusted to have an operating frequency of 10.229 999 999 543 MHz (i.e., -38.597 μsec/day).[136] The fixed relative velocity calculated in Eq. (62) is only true for a ground station at one of Earth's poles. However, for other latitudes, the actual relative velocity between a ground station and a GPS SV according to vector subtraction will vary over the satellite orbit. In reality, the Δt_{SR} term is not a constant, being dependent on the dynamic geometric relationship between the respective tangential velocities of a particular ground station and an orbiting SV. For example, relative to hypothetical ground stations located on the Equator, the velocity of an SV at inclination 51° can vary somewhere between 3642–4182 *km*/*s* depending on the ground track of the SV. The complete Δt_{GR} term, which must include the gravitational effects of the Sun and the Moon, is also not fixed in time. Small variations in this term occur due to the dynamical geometry of a satellite orbit relative to the Earth, Sun and Moon. However, the relativistic terms may be integrated

over the entire orbit and precisely determined for a particular GPS monitoring station. Clearly, the intention of the GPS clock frequency offset is to induce orbiting GPS clocks to tick at a rate that is *similar* (rather than identical) to the tick rate of ground clocks in accord with modeled relativistic effects.

Time and frequency metrology (i.e., the science of precision timekeeping) is intrinsically dependent on statistics and probability. The measurement of time is based on process, and the assumption that a particular process used as a reference definition for time measurement, when repeated, will always exhibit the identical quality of what we measure as time. Experience shows that two clocks that might appear to agree on the time, never agree perfectly at some level of time measurement resolution. To a very small part of a measured second, and some period after being initially synchronized and syntonized, two atomic clocks will not agree on the time. So, which one of the clocks reads the "correct" time? — There is really no way to tell. — We can best define the time scale to be the computed average of a "well-behaved" clock set and we identify the best individual clocks as those clocks that consistently show the smallest deviation in reference to this statistical "paper clock."

Individual clocks can only be judged in reference to their conformity or lack thereof to a well-behaved set of other clocks. The rate of a well-behaved clock generally conforms with other clocks in the set, therefore not exhibiting undue deviation from the average behavior. Modern timing centers all use an ensemble of atomic clocks together with weighting algorithms that make each additional clock in the set improve the overall performance of the ensemble, which is output in the form of a statistically averaged paper clock. One may then carefully "steer" a real physical clock to mimic the time scale as realized by the clock ensemble so as to have a real-time electronic reference to this time scale, which will greatly exceeds the performance of any particular individual clock.

> GPS system time is given by its Composite Clock (CC). The CC or "paper" clock consists of all operational Monitor Station and satellite frequency standards. GPS system time, in turn, is referenced to the Master Clock (MC) at the USNO and steered to UTC(USNO) from which system time will not deviate by more than one microsecond. The exact difference is contained in the navigation message in the form of two constants, A0 and A1, giving the time difference and rate of system time against UTC(USNO, MC).[137]

The steering of GPS system time involves individual corrections based on empirical measurements of satellite clock readings that are regularly sent to each of the GPS satellite clocks from ground antennas. Without these daily corrections, the accuracy of GPS would rapidly deteriorate. GPS is fundamentally a practical system designed to achieve a specific mission. Therefore, engineering solutions would be implemented to mitigate unexpected clock behavior due to an unmodeled relativistic effect that affects the accuracy of the system. However, the dynamical effect of *TGR* on the relative rate of GPS satellite clocks is so extremely complex that there was no possibility of modeling it and entirely eliminating it based solely on empirical data; an understanding of the *TGR* phenomenon is essential.

Einstein's version of relativity recognizes two and only two phenomena that affect the relative rate of ideal clocks: altitude in a gravitational field and relative motion. — Consider now the heretofore unmodeled effect of transverse gravitational redshift on the behavior of a GPS SV clock relative to a particular ground station (e.g., the GPS Master Control Station near Colorado Springs). Similar to the Δt_{SR} term, the Δt_{TR} (transverse redshift) term varies over the orbit, being dependent on the transverse component of the actual or virtual signal path between the SV and a ground station. The minimum effect will occur at two points in the orbit: at transit and also at "anti-transit," which is the moment when the satellite transits over the antipode to the ground station. It follows that *TGR* will impose an unmodeled *sinusoidal* modulation on satellite clock rate relative to a reference ground clock with a period equal to the satellite orbit period (~12 hours). Moreover, a particular GPS SV clock will in general run somewhat slower than a reference ground clock as compared to comprehensive calculations that neglect to account for the relativistic transverse redshift effect. In early tests of the developing GPS, the *TGR* effect was apparently recognized empirically, identified in a 1988 paper sourced from the Naval Surface Warfare Center entitled, "Orbit period frequency variations in the GPS satellite clocks." Coincidental relationships led investigators to assume that the observed variations were caused by thermal cycling.

TGR affects the relative rate of ground clocks as well as satellite clocks. Relative to a reference master clock, only a remote clock located at the antipode to the reference clock will behave according to the conventional relativistic model. Otherwise, the virtual signal path between two clocks through the interior of the Earth incorporates a transverse component. Consequently, the clocks of each GPS Ground Control Segment Monitoring Station will run somewhat slower relative to the Master Clock in Colorado than currently modeled by Einstein's relativity. Although the monitoring stations are obviously not moving away from one another, due to *TGR*, their respective clocks will behave as if a small 'virtual' recessional velocity exists that causes a symmetric relativistic time dilation effect (i.e., a *redshift*). This redshift is similar in nature to the cosmological redshift, which is also not associated with a real recessional motion.

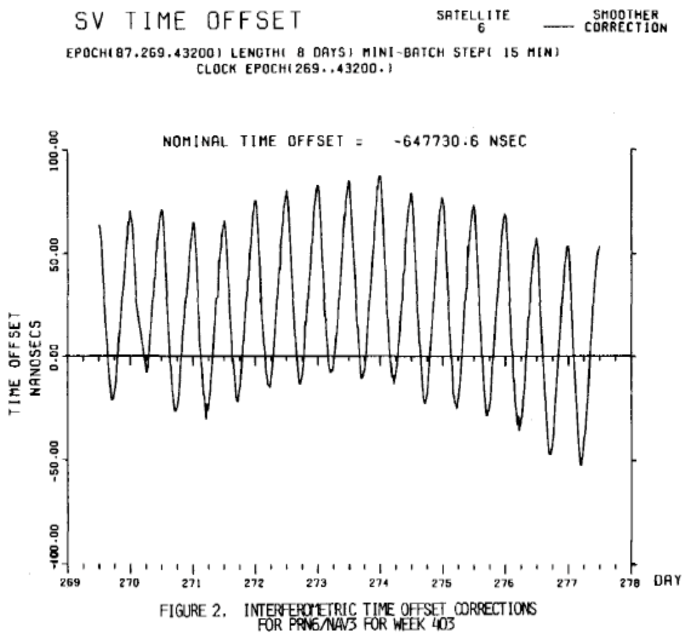


Figure 59 | Interferometric time offset corrections for a GPS satellite in 1987. Figure 2 from Everett R. Swift and Bruce R. Hermann, "Orbit Period Frequency Variations in the GPS Satellite Clocks," *Proceedings of the Annual Precise Time and Time Interval (PTTI) Systems and Applications Meeting (20th) Held in Vienna, Virginia on 29 November-1 December 1988*.[138] Note that the period of the oscillation is equal to the orbital period of the satellite (very nearly 12 hours).

Based on the persistent observed anomalous behavior of GPS clocks, investigators have already suspected a relativistic modeling error. The following quotation is taken from a 2005 report sourced from the U.S. Army Research Laboratory in Adelphi, Maryland.

> The principle [sic] reason for investigating in detail relativistic effects is to improve the current accuracy of GPS and to create future time transfer and navigation systems that have several orders of magnitude better accuracy. At the present time, it is well-known that small anomalies exist in position and time computed from GPS data. The origin of these anomalies is not understood. In particular, GPS time transfer data from the U.S. Naval Observatory indicates that GPS time is periodic with respect to the Master Clock, which is the most accurate source of official time for the U.S. Department of Defense. Furthermore, other anomalies have been found in Air Force monitor station data that are not understood at present.[139]

As outlined in *Section 17*, the principles of relativity imply a transverse gravitational redshift, which has heretofore never been recognized, let alone modeled. With the exception of the static limb effect for which a promising yet only tentatively correct calculational method (pending empirical verification) was presented in *Section 19*, accurate prediction of *TGR* for GPS generally requires numerical solutions implemented in software. It is virtually certain that the primary source of unexplained observed errors in GPS is *TGR*. A more detailed discussion of this topic is beyond the scope of this dissertation.

22. THE EFFECT OF *TGR* ON SATELLITE GEODESY

The various successive versions of the U.S. Department of Defense World Geodetic Systems (WGS) were heavily influenced by Doppler satellite geodesy. In the development of the World Geodetic System 1972 (WGS72) and later the current WGS84, which was developed as the improved coordinate reference frame for the nascent Global Positioning System, most datum parameters were influenced by Doppler satellite measurements.[140] The following is taken from *The Global Positioning System Geodesy Odyssey*, a definitive historical and technical review of the GPS by Alan Evans *et al*. (2002).

> The preliminary WGS84 coordinates of the USAF [United States Air Force] and DMA [Defense Mapping Agency] GPS tracking stations were obtained by transformation from their WGS72 coordinates. During 1985 and 1986, the WGS84 coordinates were directly derived using Doppler TRANSIT point positioning by DMA. This positioning technique used the recently calibrated WGS84 Doppler station coordinates, Doppler observations collected from TRANSIT satellites, and the WGS84 gravity model. The WGS84 positions of the GPS tracking stations were defined by transferring WGS84 positions of nearby collocated Doppler stations using terrestrial survey differences.
>
> Uncertainties in these Doppler-derived WGS84 station coordinates were attributed principally to uncompensated ionospheric effects on signal propagation and, to a smaller extent, the determination of the electrical phase center of the antennas. TRANSIT, like GPS, used dual-frequency observations to correct for ionospheric effects. This correction's residual errors are inversely proportional to the satellite transmitted frequencies. Ionospheric corrections for the TRANSIT low-frequency observations contained relatively large residual errors; these errors primarily corrupted the height of Doppler-derived coordinates. Smaller errors in the GPS station coordinates were introduced by inaccurate definitions of the electrical phase center of both the TRANSIT and GPS antennas used in the coordinate transfers. The combination of these and other errors made the initial GPS station coordinates internally inconsistent and biased with respect to the BTS [Bureau International de l'Heure Terrestrial System]. The largest bias, which was in the GPS station heights, was estimated to be at the meter level.[141]

The International GPS Service (IGS) antenna at Diego Garcia is on an island atoll that is part of the Chagos Archipelago in the British Indian Ocean Territory just south of the Equator.[142] As is common to virtually all such island atolls, the terrain has an average elevation of about 1–2 meters above local sea level and a maximum elevation not exceeding 10 meters. The IGS antenna at Kwajalein is on a very similar island atoll that is part of the Marshall Island Group in the North Pacific Ocean, about half way between Hawaii and Australia just north of the Equator.[143] Fig. (60) shows the geographic locations of these two remarkably similar islands, both of which are surrounded by vast expanses of open ocean near the Equator. Aerial photographs of the two islands are shown in Fig. (61) so that one may appreciate their virtually identical completely flat topographies at sea level.

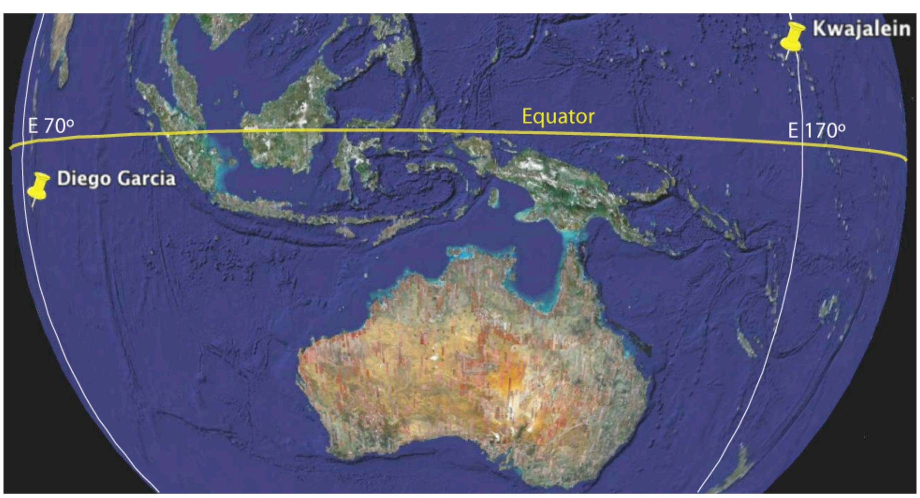


Figure 60 | Geographic locations of Diego Garcia and Kwajalein. Map by *Google Earth*.

~ 72º22' E, 7º16' S

~ 167º43' E, 8º43' N

Figure 61 | Aerial photographs of Diego Garcia and Kwajalein Atolls.
Photos courtesy Unites States Department of Defense.

Intuitively, the surface of an undisturbed body of water represents a plane perfectly orthogonal to the local gravitational gradient. Disturbances may cause temporary deviation from the mean water surface, but the nature of a fluid in a gravitational field implies that its surface will self-equalize. In spite of their size and the fact that the applicable gravitational field is spherical rather than planar, the world's oceans clearly must subscribe to this principle. The Permanent Service for Mean Sea Level (PSMSL) is the global data bank for sea level change information established in 1933 in the United Kingdom. According to the PSMSL, Mean Sea Level (MSL) is the local height of the global Mean Sea Surface above a "level" reference surface, or datum, called the geoid. There is a sea level difference of about 20 centimeters across the Panama Canal, which has been accurately measured by geodetic leveling from one side to another. The Atlantic Ocean surface as a whole is considered to be about 40 centimeters lower than the surface of the Pacific due to differences in density and prevailing weather conditions. An apparent notably large variation in mean sea level results from the southerly Gulf Stream current in conjunction with the Earth's rotation, which is reported to cause about a one meter difference in mean sea level height between New York and Bermuda.[144]

The Earth's geoid as defined by the United States National Geodetic Survey is

> "The equipotential surface of the Earth's gravity field which best fits, in a least squares sense, global mean sea level."[145]

Then the geoid is that smooth surface that closely approximates the mean sea surface and is everywhere perpendicular to a local plumb line defining the direction of the local gravitational gradient. One should be aware in this discussion that the Jason-1 and TOPEX/Poseidon satellites, which map ocean surface topography, actively reference GPS in real time; these two systems are not independent of GPS, so their data will incorporate any GPS error.[146,147] In a publication entitled "Vertical Datums, Elevations and Heights," the U.S. National Imagery and Mapping Agency (NIMA) states (emphasis in the original):

> It turns out that MSL is a close approximation to another surface, defined by gravity, called the **geoid**, which is the *true zero surface for measuring elevations*. Because we cannot directly see the geoid surface, we cannot actually measure the heights above or below the geoid surface. We must infer where this surface is by making gravity measurements and by modeling it mathematically. For practical purposes, we assume that at the coastline the geoid and the MSL surfaces are essentially the same. Nevertheless, as we move inland we measure heights relative to the zero height at the coast, which in effect means relative to MSL.[148]

Armed with the foregoing, one might reasonably estimate that the maximum mean sea level differential between Kwajalein and Diego Garcia is less than one meter. The topography of the two islands and the fact that both antennas are mounted in nearly identical fashion within a few meters of the ground then imply that the two respective antennas are at nearly identical elevations relative to the geoid.

The Global Positioning System measures elevation not relative to the geoid *per se*, but relative to a theoretical equipotential ellipsoid of revolution specified by the World Geodetic System 1984 (WGS84) which was designed for use as the reference system for GPS. The relationship between the ellipsoid height h that is specified by GPS, the height H of the topographic surface of the Earth above the geoid and the geoid height N relative to the ellipsoid is $h = H + N$. At mean sea level, by definition the value of H is zero, so here the ellipsoid height reported by GPS is then equal to the geoid height relative to the ellipsoid, which at sea level should also be close to zero.

Although the equivalent of mean sea level over the entire Earth's surface does not describe a perfect ellipsoid, the perfectly smooth and well-defined mathematical surface of the equipotential ellipsoid furnishes a simple, consistent and uniform reference system for geodesy (surveying) and geophysics (study of the Earth's interior).[149] The parameters of the reference ellipsoid, the semi-major axis a, and the flattening f have been chosen so that the ellipsoid might very closely follow the geoid. The geoid height N or "undulation of the geoid" relative to the ellipsoid should represent to good approximation the effects of gravitational anomalies due to density variations in the Earth's interior. These density variations can be tested to an accuracy of about 2 μGal (2×10^{-8} m/s^2) using an absolute gravimeter such as the Micro-g Solutions FG5 absolute gravimeter or, even better, a triumvirate of these very accurate instruments whose local independent redundant readings by distinct teams can be compared for error detection.[150, 151]

With all of the foregoing in mind, consider now that the published GPS reference height of the Kwajalein IGS antenna (kwj1) is 38.000 meters *above* the ellipsoid and the published GPS reference height of the Diego Garcia IGS antenna (dgar) is 64.7455 meters *below* the ellipsoid.[152] This is a stunning discrepancy of over 100 meters in their relative ellipsoid heights, which have been specified to an accuracy of 10^{-4} meter! When its full capacities are used by authorized personnel in differential mode, as verified by a laser rangefinder, GPS has been advertised to be very accurate in discriminating between two distinct locations that are within line of sight from one another. Accuracy in specifying the distance between two points that is on the order of one centimeter has been demonstrated. It is then easy to assume that all coordinates generated by GPS reflect empirical reality to high accuracy. However, from a geodetic and geophysical perspective, these ellipsoid elevation discrepancies simply do not make sense. They must be considered just as troubling as the purported anomalous acceleration of the Pioneer spacecraft, discussed in the next section. "A geoid which undulates wildly across the landscape" almost certainly does not reflect empirical reality.[153] Perhaps the considerable distance (~10,700 km) between Kwajalein and Diego Garcia may give one the false impression that such a large ellipsoid height differential for locations, which are both in the open ocean near the Equator, could possibly be reasonable. The following should erase any doubt that something is indeed seriously amiss.

Malé International Airport on Hulhule Island in the Maldives is located 1,270 *km* north of Diego Garcia in the Indian Ocean as shown in Fig. (62). It's official runway elevation is 6 feet (~2 meters) ASL.[154]

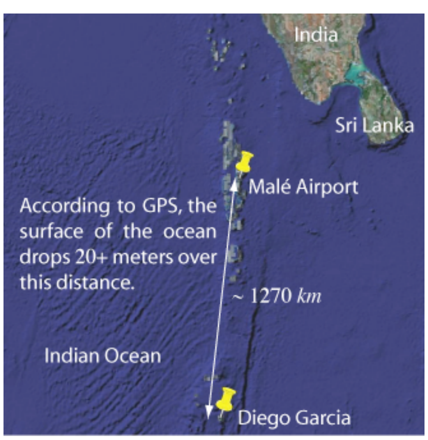


Figure 62 | Geographic location and aerial photograph of Malé Airport, Maldives.
Map by *Google Earth*. Photo courtesy John S. Goulet (ebushpilot.com).

The Malé Airport IGS station is located at 73º31'35" E, 4º11'19" N with an antenna fixed to a post approximately 2.3 meters high. However, its reported GPS reference ellipsoid height is *minus* 92 meters, using the same WGS84 coordinates as for Diego Garcia and all other IGS stations.[155] This is a discrepancy of 27.25 meters over a distance of only 1,280 kilometers. According to the GLOSS handbook, tide levels at Hulhule Island are similar to those at Diego Garcia and Kwajalein.[156] It is by rigorous definition that the ellipsoid very nearly follows the ocean surface of the oblate Earth, particularly for the open ocean near to the Equator.

> The geoid is an equipotential surface of the Earth's gravity field that is closely associated with the mean ocean surface. "Closely associated" can be defined in a number of ways [*Rapp*, 1995]. A working concept is that the mean difference between a geoid and the mean ocean surface should be zero. Deviations between the mean ocean surface and the geoid represent (primarily) mean Dynamic Ocean Topography (DOT). The standard deviation of the DOT is approximately ± 62 cm, with extreme values from about 80 cm to about –213 cm, the latter in the Antarctic Circumpolar Regions (e.g., 66˚S, 356˚E).[157]

However, it is quite clear that Malé Airport is not 92 meters (over 300 feet) under water, so how do we justify the GPS ellipsoid height of 92 meters below the ellipsoid with the fact that Malé Airport is a place for airplanes and not submarines? In the absence of any theoretical model that might otherwise explain GPS results, which have been accepted as very accurate empirical data, geodesists have had no choice but to invent something called a "gravity disturbance" to model the anomalies that appropriately shocked geodesy experts who had realistically expected to measure a far smoother terrestrial geoid.[158]

> The NASA Goddard Space Flight Center (GSFC), the National Imagery and Mapping Agency (NIMA), and the Ohio State University (OSU) have collaborated to develop an improved spherical harmonic model of the Earth's gravitational potential to degree 360. The new model, Earth Gravitational Model 1996 (EGM96) incorporates improved surface gravity data, altimeter-derived anomalies from ERS-1 and from the GEOSAT Geodetic Mission (GM), extensive satellite tracking data – including new data from Satellite laser ranging (SLR), the Global Positioning System (GPS), NASA's Tracking and Data Relay Satellite System (TDRSS), the French DORIS system, and the US Navy TRANET Doppler tracking system – as well as direct altimeter ranges from TOPEX/POSEIDON (T/P), ERS-1, and GEOSAT. The final solution blends a low-degree combination model to degree 70, a block-diagonal solution from degree 71 to 359, and a quadrature solution at degree 360. The model was used to compute geoid undulations accurate to better than one meter (with the exception of areas void of dense and accurate surface gravity data) and realize WGS84 as a true three-dimensional reference system. Additional results from the EGM96 solution include models of the dynamic ocean topography to degree 20 from T/P and ERS-1 together, and GEOSAT separately, and improved orbit determination for Earth-orbiting satellites.[159]

Using a spectrum of colors to represent geoid heights relative to the zero reference point, Fig. (63) shows mean values of geoid undulations computed from EGM96 to degree and order 360. The values refer to the WGS84 (G873) system of constants, which provide a realization of the geometry and the normal gravity potential of a mean-Earth ellipsoid. The permanent tide system is "non-tidal," and the units are meters.[160] The EGM96 model (1996) was superseded by EGM08 in 2008, but as of the release of this manuscript, a geoid undulation plot like that shown in Fig. (63) that is based on the new model has yet to be posted on the National Geospatial-Intelligence Agency Web site. One can assume that the new model provides better resolution, but does not greatly alter the prior model. In the vicinity of the GPS Operational Control Station at Diego Garcia, we see a huge purple splotch about 2,500 *km* in diameter in the middle of the ocean on the EGM96 geoid. Notice that the giant minus one-hundred meters (-100 *m*) purple splotch in the EGM96 geoid is coincidentally adjacent to Diego Garcia, the farthest GPS OCS Monitoring Station from the USNO Alternate Master Clock (AMC) in Colorado Springs nearly on the opposite side of the globe. Does it represent what it purports to be on these maps, or is it something else? To find out we need to make absolute gravity measurements specifically on Malé and also on Diego Garcia and Kwajalein and compare them, but there seems to be no evidence in the literature of such measurements. Moreover, there is an indication that when the satellite data disagrees with precise and reliable surface gravimetry data, it is surprisingly the latter data that has been generally "downweighted" to one degree or another, rather than identifying the problem causing the dissimilar information.

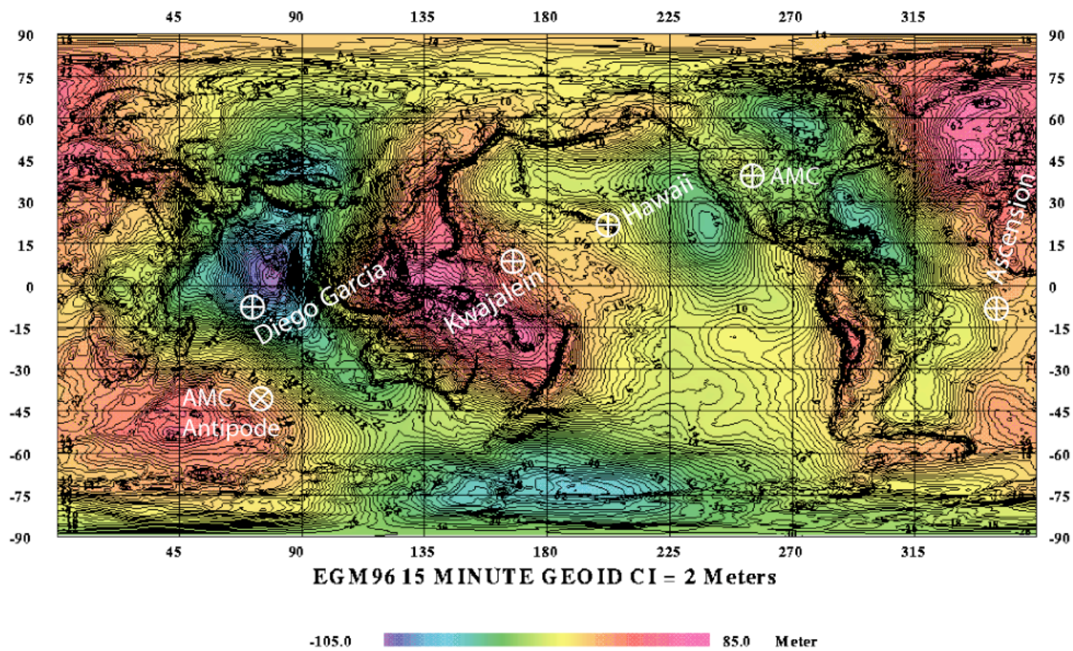


Figure 63 | EGM96 15' x 15' geoid undulation plot. GPS Monitor Station locations added.
Courtesy National Geospatial-Intelligence Agency [161]

The emphasis has been added to the following quotation.

> EGM96, through its incorporation of newly available surface gravimetry has significantly improved continental geoid modeling. The new data include contributions over most of Asia and the former Soviet Union, airborne gravity surveys over polar regions including Greenland, surveyed data from South America, Africa, and North America, as well as improvements to the data sets provided by many countries. These data enhancements have all increased the short wavelength global geoid accuracy of the resulting model. Of importance is the progress which was achieved in eliminating a significant level of *inconsistency between the geopotential signal sensed by satellite tracking versus terrestrial anomaly data*. Earlier combination solutions "required" (given model design considerations) the strong downweighting of surface gravimetry (for example in JGM-2 and JGM-3). EGM96 gave much higher weight to the surface information, yet still performs well on orbital and ocean geoid modeling applications. [162]

In order for the Earth's diurnal rotation to be free of significant non-precessional wobbling as observed, contrary to the EGM96 model, the geoid must be remarkably smooth. Because the GPS is a product of people and facilities located in the United States, it would make sense that any free parameters that might be manipulated to improve its positional accuracy would have been adjusted so as to make inaccuracies a minimum in and around the continental United States. The implication is that errors in GPS satellite geodesy caused by unmodeled *TGR* would tend to increase with distance from the United States.

> The accuracy for dynamic geodesy and—to a large extent—all space geodesy, is dependent on accurate positioning of the satellite. In turn, satellite orbit computation accuracy (and satellite ephemeris accuracy) is dependent on the accuracy of the space geodesy. Satellite observations made from the ground can be used accurately only if the ground station locations are known accurately, while the orbit itself can be computed accurately only if all of the forces governing the satellite motion are known. The early dynamic geodesists observed satellite prediction errors and made bootstrap corrections to the gravity models. GPS benefited greatly from the existing WGS gravity model. Techniques that eliminate common-mode errors among ground locations provide improved accuracy over limited distances, but they still depend on satellite position accuracy. GPS geodesy, like GPS navigation, relies on the accuracy, quality, and timeliness of the orbit computation and prediction. [163]

23. *TGR* AND CELESTIAL MECHANICS

It is essential to appreciate that relativistic transverse gravitational redshift (*TGR*) is a phenomenon that must be applicable to the translation of energy in the form of mass as well as radiation. Consider an assumed ideal circular orbit of a test body in a static symmetric gravitational field. According to temporal geometry, the neighborhood of each unique point along the orbit is associated with a unique time coordinate that is not parallel to any of the respective time coordinates of the other points along the orbit. It follows that there is an energy cost incurred in a circular orbit, so the orbit cannot actually be circular; rather it must be a very gradual inbound spiral implying a secular decrease in the orbital radius. If there are no overpowering forces at work, such as angular momentum transfer (e.g., tidal dissipation) from the gravitational source body to the test body, the orbit will exhibit accelerating decay as the local escape velocity increases and the orbital period steadily decreases; a stronger gravitational field implies an increase in the magnitude of the *TGR* effect for a complete orbit and a shorter orbital period implies that this larger effect occurs in a shorter amount of time. In practice, an artificial satellite (e.g., LAGEOS) is subject to the gravitational effects of the Earth, the Moon and the Sun, each of which will contribute some *TGR* effect to the orbit. On the other hand, for the natural satellites Phobos (Mars) and Io (Jupiter), the gravitational effects of the host planet strongly dominate, even compared to the Sun. Additionally, binary star systems, orbiting stars in galaxies, and co-orbiting galaxies in clusters will be subject to *TGR*.

Recent precision observations confirm that Mars' tiny satellite, Phobos, incurs a secular acceleration of $+136.7 \pm 0.6 \times 10^{-5}$ deg/yr^2. [164] This implies a secular decrease in the mean orbital radius of about 4 *cm*/*yr* correlated to a secular dissipation in Phobos' orbital energy of about 3.3 megawatts in the current epoch. Energy conservation implies that the energy dissipated by Phobos must take another form. The currently accepted explanation of the phenomenon is that Phobos produces a gravitational tidal bulge on the surface of Mars and exerts a torque on this bulge, so that the energy lost by Phobos produces a secular increase in the angular momentum of Mars. An examination of the physical system reveals that this is an unlikely if not unreasonable explanation that is reminiscent of epicycles. If tidal dissipation is not the correct explanation of the observed phenomenon, another explanation is required.

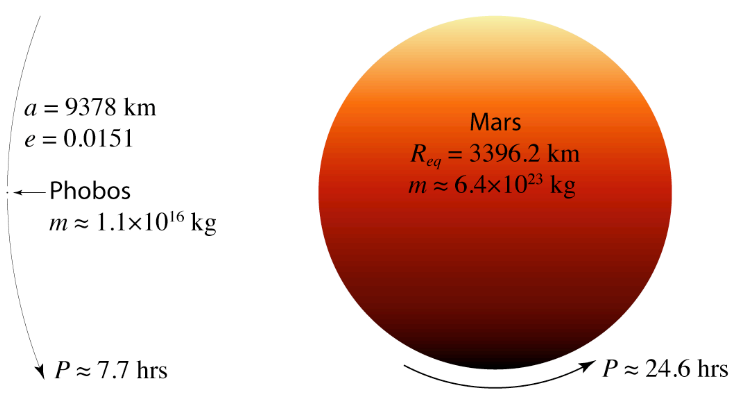


Figure 64 | Mars and its satellite Phobos drawn to scale. In order for the observed secular acceleration of Phobos to be caused by tidal dissipation, Phobos must exert a torque on a tidal bulge it creates on Mars. This precisely accurate scale diagram suggests that this is not possible.

A mass directly under Phobos on the surface of Mars experiences a vertical gravitational acceleration towards Phobos of about 2×10^{-8} m/s^2. In comparison, the Moon produces an acceleration at the surface of the Earth below it that is between about 1500–2000 times greater, with the variation due to its eccentricity. Consequently, even if we assume a hypothetical Mars covered with a deep ocean of water over most of its surface in the current epoch, as is true for the Earth, no tides induced by Phobos would be observed. Moreover, in its very nearly circular and equatorial orbit (inclination 1.08°), Phobos moves across the sky very rapidly, covering about +32 degrees per hour relative to the rotating surface of Mars. Even if there were adequate gravitational force to produce a tidal bulge in the solid crust of Mars, there is inadequate time for bulk flows to produce deformation. At least the differential rotation rates of Phobos and Mars

cause the satellite to lead a hypothetical tidal bulge on Mars, so it is not completely irrational to imagine that tidal dissipation causes the observed secular acceleration of Phobos. However, this does not hold for Jupiter's innermost moon, Io; the Solar System's primary candidate for demonstrating the phenomenon of tidal dissipation exhibits precisely the opposite of the expected modeled behavior.

Figure 65 | Jupiter and its moon Io drawn to scale. Similar to the Earth-Moon system but just the opposite of Mars and Phobos, Jupiter's sidereal rotation period is considerably shorter than the orbital period of Io. Just like Phobos, Io has a very nearly circular and equatorial orbit (inclination 0.04°). Clearly, any tidal bulge in the surface of Jupiter produced by Io must lead the moon due to Jupiter's rapid rotation rate. The angular momentum transfer is *from Jupiter to Io*, so this moon is expected to exhibit a secular *increase* in its semi-major axis. However, just like Phobos, Io exhibits a secular *decrease* in its semi-major axis, which implies an unmodeled energy dissipation phenomenon.

Following is the complete abstract from a 1995 paper by Goldstein and Jacobs:

> From reanalysis of 17th century and 20th century eclipse observations, with three different models for the Earth's rotation, and from the use of both longitude comparison and mean motion comparison, we find that Io has a fractional acceleration of $(4.54\pm0.95)\times10^{-10}$ yr^{-1}. If Io can be considered a Keplerian oscillator, its orbital semi-major axis *decreases* by 13 *cm/yr*.[165]

Following is an excerpt from the abstract of a 2001 paper by Aksnes and Franklin:

> Our determination of $\dot{n}_1/n_1$ is in reasonable agreement with the values 3.3±0.5 (from de Sitter, published in 1928) and 4.54±0.95 (from Goldstein & Jacobs, published in 1995), both of which were derived from analyses of eclipses of the satellites by Jupiter and some photographic observations. However, it conflicts with the value -0.074±0.087 found by Lieske (published in 1987) from Jovian eclipse timings. Our results imply that Io is now spiraling slowly *inward*, losing more orbital energy from internal dissipation than it gains from Jupiter's tidal torque.[166]

In theoretical physics it is important to make a distinction between fundamental first principles such as energy conservation and speculative models of observed phenomena linked to those first principles. Accordingly, while the observed secular acceleration of Phobos does imply some phenomenon of energy transfer, it is not necessarily the case that this phenomenon is tidal dissipation. The apparent secular acceleration of Io provides convincing if not conclusive evidence of an energy dissipation phenomenon associated with orbital motion in a gravitational field that is unrelated to tidal dissipation. Moreover, ubiquitous observation of secular spin-down of stars and planets is indicative of the same phenomenon.

Evidence from numerous and varied empirical observations strongly suggests that transverse motion in a gravitational field produces a small counteracting force that does work, causing decay of orbits as well as spin-down of rotating bodies. — Consider the case of Pioneer-10, depicted in Fig. (66). The trajectory taking the spacecraft out of the Solar System had a distinct component transverse to the solar gravitational gradient as was also true for the Pioneer-11 spacecraft. The implication of *TGR* applied to orbits is that the spacecraft would have consistently lost a small amount of its orbital energy relative to the Sun. Consequently, the magnitude of the outbound radial velocity can be expected to have been very slightly less than the modeled behavior according to precise calculations of all forces acting on the spacecraft.

A natural interpretation of the observable, which was accurately measured using Doppler radio telemetry, is the assumed existence of an unmodeled excess radial acceleration of the spacecraft *towards* the Sun. However, *TGR* acceleration retarding transverse motion (tangent to the solar gravitational gradient) would have slightly reduced the orbital energy, providing the compelling illusion of a small excess acceleration towards the Sun. Thus, the phenomenon behind the *Pioneer Anomaly* is almost certainly identical to the phenomenon causing the observed secular acceleration of Phobos and Io and other previously observed but unexplained anomalous astrophysical and spacecraft ephemerides.

> Our previous analyses of radio Doppler and ranging data from distant spacecraft in the solar system indicated that an apparent anomalous acceleration is acting on Pioneer 10 and 11, with a magnitude $a_P \sim 8\times10^{-8}$ cm/s^2 , directed towards the Sun. Much effort has been expended looking for possible systematic origins of the residuals, but none has been found.[167]

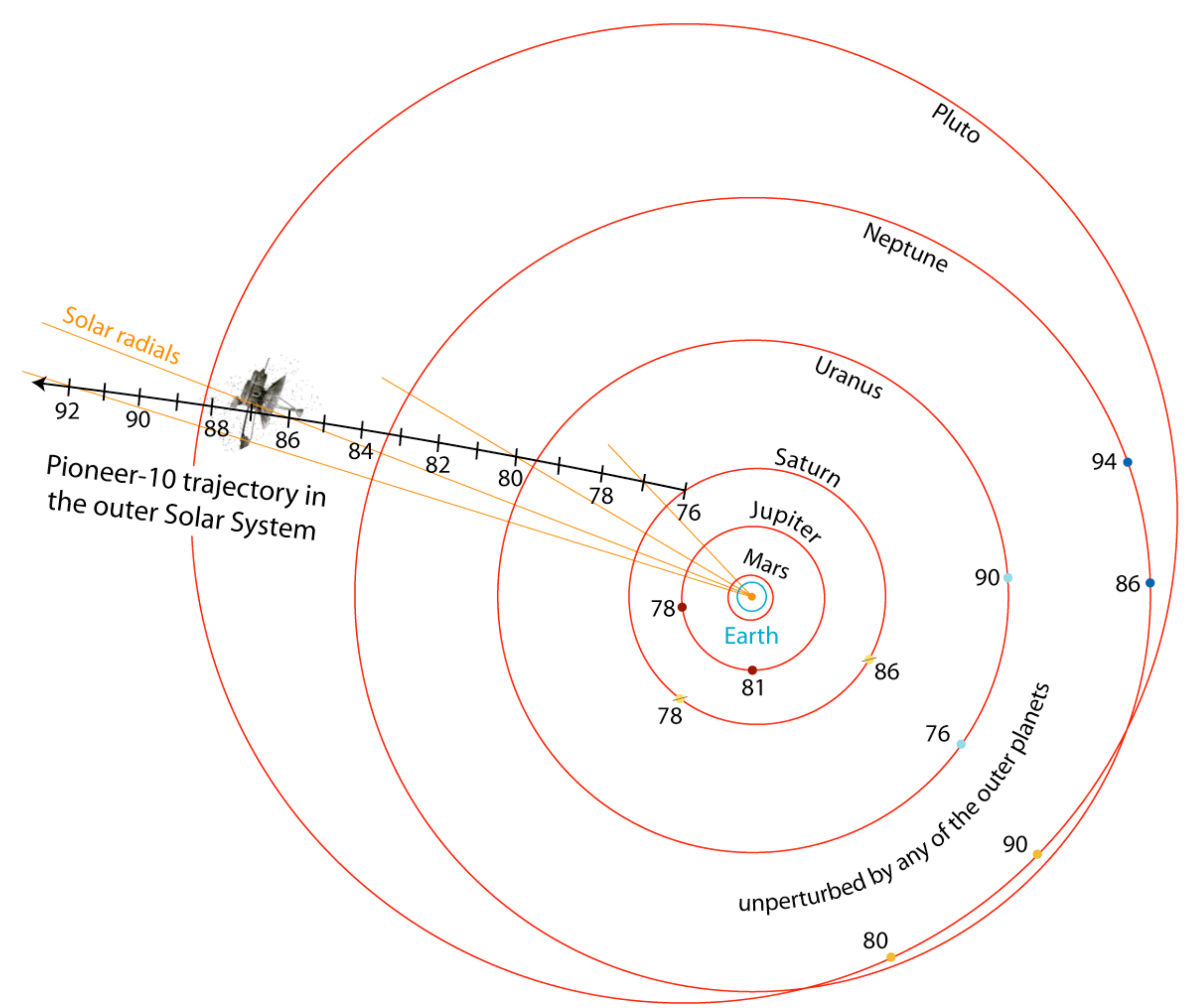


Figure 66 | Ephemerides of the Pioneer-10 spacecraft and the outer planets.

The unmodeled observed sinusoidal annual and diurnal variations of the Pioneer-10 radio Doppler signal provides additional convincing corroborating evidence for the *TGR* effect. — The heliocentric ecliptic latitude of the spacecraft remained between 3.0 and 3.15 degrees after 1977. Consequently, once per year in June, when the Sun was between the Earth and the spacecraft at conjunction, the telemetry signal path had a maximum transverse component relative to the solar gravitational field. At opposition in

December, this solar transverse component was essentially zero. The orbital motion of the Earth between these two points produces a sinusoidal variation in the transverse component as shown in Fig. (67).

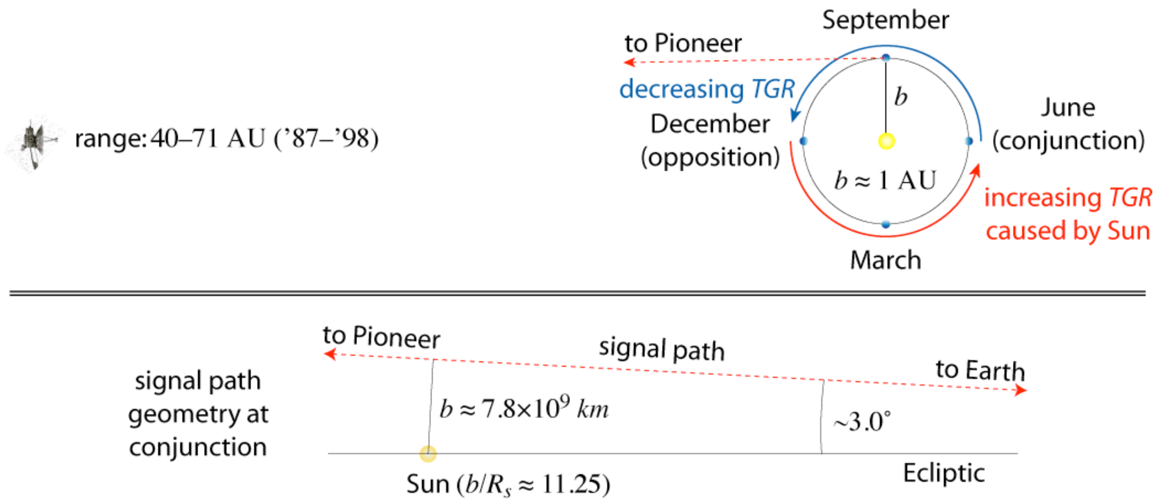


Figure 67 | Pioneer-10 annual variation in signal path geometry relative to the Sun.
The maximum *solar TGR* on the signal occurs in June and there is essentially no effect in December. The variation of the transverse component over the year due to the Earth's orbital motion should cause an anomalous sinusoidal variation in the Doppler signal. This is exactly what was observed.

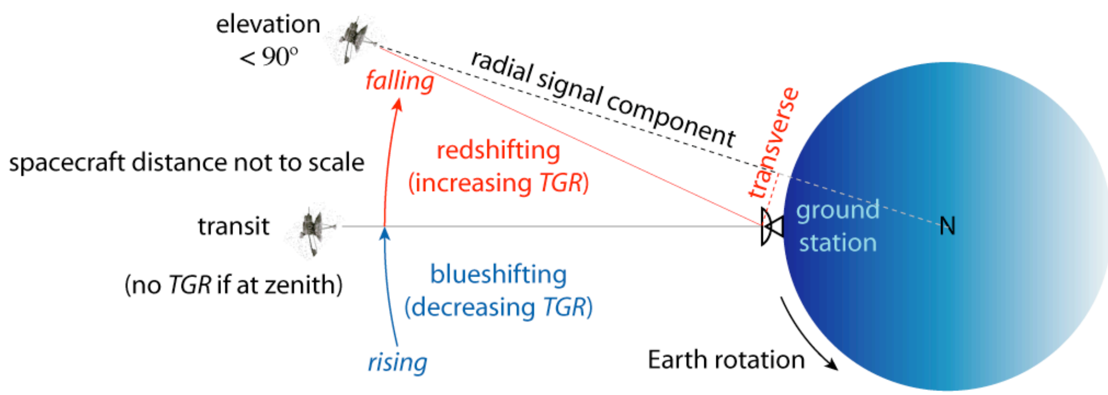


Figure 68 | Pioneer-10 diurnal variation in signal path geometry relative to the Earth.
Just like a distant planet in the Ecliptic plane, the Pioneer spacecraft rises and falls once per day relative to a ground station. As the spacecraft rises from the horizon towards transit, the transverse component of the signal path decreases, producing an anomalous blueshifting. Following transit, the transverse component of the signal path increases as the spacecraft falls towards the horizon, producing an anomalous redshifting. Therefore, the *TGR* effect should cause an anomalous diurnal sinusoidal variation in the Doppler signal. This is exactly what was observed.

The *Pioneer Anomaly* is best known for its claim of an unexplained apparent small excess acceleration of the spacecraft towards the Sun. Just as significant, but less well known, are the observed anomalous annual and diurnal variations of the Doppler signal. Given that *TGR* is an unmodeled consequence of the fundamental principles of relativity and that the Pioneer-10 spacecraft was among the most sensitive detecters of Solar System modeling errors ever employed, it was inevitable that the radio science data from the spacecraft would reflect all of the predicted physical effects of the phenomenon.

Anderson, Laing, Lau, Liu, Nieto and Turyshev

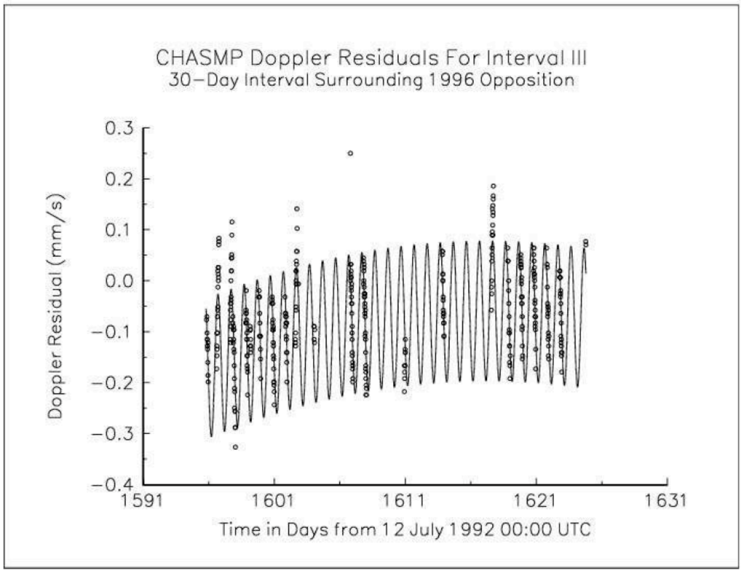


FIG. 18: CHASMP acceleration residuals from 23 November 1996 to 23 December 1996. A clear modeling error is represented by the solid diurnal curve. (An annual term maximum is also seen as a background.)

Figure 69 | Reported Pioneer-10 Doppler residuals around opposition.[168] Opposition occurred on 7 December, which is day 1609 on the *x*-axis. The solid curve is an approximate interpretation based on the individual data points taken at different times by one of the three 70-meter JPL DSN (Deep Space Network) antennas located in California, Australia and Spain. As confirmed by the paper's FIG. 8, which graphs Doppler *velocity* over time, in this particular graph (FIG. 18) a negative *Doppler Residual* reflects an excess redshift, so the visible "annual term maximum" at opposition correlates to the end of the decreasing *TGR* phase of the orbit (i.e., blueshifting) shown in Fig. (67). The Pioneer Doppler data was subject to processing and filtering based on the expectation that the measured behavior must closely reflect modeled behavior. Consequently, the reported magnitude of the anomaly is less significant than the qualitative form of the data exhibiting both the annual and diurnal sinusoids consistent with and predicted by relativistic *TGR*.

The combination of having observed both the expected annual and diurnal sinusoidal variations in the Pioneer Doppler signal as well as the expected apparent excess acceleration of the spacecraft towards the Sun is in itself compelling qualitative empirical verification of the *TGR* effect. A key realization is that the *Pioneer Anomaly*, in the form of the observed and measured *apparent* excess acceleration of the spacecraft towards the Sun, is indicative of an energy dissipation phenomenon. In accord with *TGR*, the actual acceleration on the spacecraft was perpendicular to the assumed direction, opposing the component of the velocity vector tangent to the solar gravitational gradient., Thus, the total energy of the spacecraft was slightly reduced, producing the convincing illusion of excess solar gravitational acceleration due to an observed deficit in the magnitude of the outbound radial velocity.

The identical relativistic gravitational phenomenon affecting the Pioneer-10 ephemeris, applied over aeons to orbiting astrophysical bodies, causes migration towards the primary source mass. Moreover, as the magnitudes of both the *TGR* effect and any counteracting tidal dissipation are inversely related to the orbital radius, multiple satellites will exhibit differential migration rates and particular satellites located in a zone where angular momentum transfer tends to balance *TGR* must exhibit orbit period oscillations.

Empirical evidence supporting this idea is found in precision ephemeris measurements of eclipsing binary star systems, among a number of other corroborating observations. These star systems reveal oscillations of the mean orbital radius driven by a heretofore-inexplicable energy loss mechanism in dynamical gravitational systems.

> The careful timing of [binary star] eclipses can reveal orbital period changes of order a part in 10^5–10^6 because deviations from an assumed ephemeris can build up over many orbits, and many systems have observational records spanning decades or more. These observational records reveal a surprising result: systems that show period changes of alternating sign (orbital period modulations) are common.[169]

The readily observable behavior of these systems due to their rapid time evolution is identical to that implied by far more subtle observations of Solar System planets due to their very slow time evolution. The phenomenon likely contributed to dominant large-amplitude cycles in planetary climate change with a period of hundreds of millions of years. Careful observation of natural and artificial satellites in the Solar System reveals a ubiquitous anomalous phenomenon: orbits decay relative to the dominant gravitational field, which may be the host planet or the Sun. In the context of conventional orbital mechanics, conservation of energy implies that what is observed is "impossible," so in the past, these empirical observations were either considered suspect, conveniently ignored, explained by inventing a possible cause based on known physics, or left open to speculation. The following is from an article by a respected team in the September 2004 issue of the esteemed, peer-reviewed *Astronomical Journal.*

> We show that the peculiar eccentricity distribution of the Hilda asteroids, objects that librate at the 3:2 mean motion resonance with Jupiter, as well as their distribution about the resonance itself, can be nicely reproduced from captured field asteroids if Jupiter has migrated sunward by about 0.45 AU over a time greater than 100,000 years. The latter is a lower limit and longer times are more likely, while the former quantity depends to some degree on the initial eccentricity distribution, but a fit to the observations fails unless it lies in the range of 0.4 to about 0.5 AU, where the lower value is particularly well established.[170]

Three papers in the 26 May 2005 issue of *Nature* by an international team argue that a number of independent observations imply planetary migration.[171,172,173] Specifically, distinct empirical evidence in addition to the Hilda asteroids indicates that Jupiter is indeed now orbiting the Sun considerably faster relative to Saturn's orbital speed than it did in the past.

> …H. F. Levison and colleagues contend that the orbits of Jupiter, Saturn, Uranus and Neptune have been disturbed in a small but significant way. They argue that the giant planets' eccentricities (the deviation of their orbits from a true circle) and inclinations (the tilt of their orbital planes) are much larger than those predicted by theories of planet formation — which implies that some process has disturbed the orbits of the giant planets since the time of their formation.
>
> …the authors show that the passage of Jupiter and Saturn through a 1:2 mean-motion resonance (MMR) can account for the orbital spacings, eccentricities and inclinations of all four giant planets. … The authors' find that the passage of Jupiter and Saturn through this resonance can excite their eccentricities and inclinations to current levels. However, Jupiter and Saturn are currently rather far from the 1:2 resonance — the ratio of their current orbital periods is near 1:2.5 — so the implication here is that these planets have since migrated through 2:1 to their present positions. This is a remarkable concept, because we usually think of the planets' orbits as being rather static and changing little over time.
>
> Another interesting finding is described in the second paper, which shows that this planet migration scheme can also account for the existence of Jupiter's Trojan asteroids. …
>
> The third paper shows that the 1:2 MMR can also be implicated in the Late Heavy Bombardment, which was a brief but intense series of impacts known to have occurred early in the Moon's history. In the authors' models, Neptune's orbit is destabilized when Jupiter and Saturn pass through the 1:2 MMR.[174]

Attempts to explain the migration of the Jovian planets in the context of ancient conventional processes are not incisive and fail to integrate the phenomenon with related empirical observations.[175,176,177]

It is well known that Io (n_1) Europa (n_2) and Ganymede (n_3) exhibit a Laplace resonance whereby

$$n_1 - 3n_2 + 2n_3 = 0.0000°day^{-1} \tag{91}$$

(Here, n_i are the mean angular velocities of the satellites.) For the observed configuration of a stable point of conjunction to evolve, it is certainly the case that a differential migration of these satellites from their random primordial configuration was required; however, no satisfactory theory exists that describes how this evolution came about while avoiding higher order resonances.[178,179]

> On the assumption that the resonance was formed by the action of tidal forces, we describe what the evolution of the system must have been like before and after the formation of the resonance. However, no satisfactory explanation of the capture into the resonance is found. It seems possible that the system could have been captured into a large amplitude libration, but it is then difficult to explain the present very small amplitude.[180]

The implication of the Galilean satellite's orbital resonance is that secular inbound migrations of Io, Europa and Ganymede at differential rates were required. It is clearly the case that such migrations allow for an initial capture into resonance of two bodies followed by a secondary capture of the third body. Clearly indicated inbound migration of the Galilean satellites relative to Jupiter is identical to that implied for the Jovian planets relative to the Sun and correlates with the observed secular acceleration of Phobos. It is clear from observations that orbits decay in the direction of the dominant gravitational field and that the conventional post-Newtonian model of gravitation does not model this behavior. If the Jovian planets have migrated towards the Sun, then both Earth and Mars have been influenced by the same phenomenon. However, the geophysical history of the Earth suggests that it exists in a special region where the effect of solar angular momentum transfer counteracts the orbit decay phenomenon. Resulting oscillations in the mean orbital radius of the Earth, which may well have multiple periods and amplitudes, must drive regular oscillations of significant planetary climate change.

> With surprising and mysterious regularity, life on Earth has flourished and vanished in cycles of mass extinction every 62 million years, say two UC Berkeley scientists who discovered the pattern after a painstaking computer study of fossil records going back for more than 500 million years…
>
> "We've tried everything we can think of to find an explanation for these weird cycles of biodiversity and extinction," [Richard] Muller said, "and so far, we've failed." …
>
> But the cycles are so clear that the evidence "simply jumps out of the data," said James Kirchner, a professor of earth and planetary sciences on the Berkeley campus who was not involved in the research but who has written a commentary on the report that is also appearing in *Nature* today. …
>
> Said Muller: "We're getting frustrated and we need help. All I can say is that we're confident the cycles exist, and I cannot come up with any possible explanation that won't turn out to be fascinating. There's something going on in the fossil record, and we just don't know what it is."[181]

As of 1 January 1998, the International Celestial Reference System (ICRS) based on the observed locations of distant quasars, which exhibit no proper motion, replaced the Fifth Fundamental Catalogue (FK5) which had briefly superseded FK4.[182,183] Required corrections in right ascension imply an unmodeled phenomenon affecting the orbital motion of the Earth. What has ironically been called the "fictitious motion of the equinox," implying disbelief in what is definitively observed, is consistent with an unmodeled secular acceleration associated with the orbital motion of the Earth, which is in discord with conventional wisdom. With the advent of new technologies and techniques in the latter half of the 20th century, space astrometry has attained unprecedented precision. A definite secular trend in the mean longitudes of planets is observed.[184] For Earth, this trend manifests as a measurable accelerating drift in the location of the equinox.[185,186,187] The observed drift in the location of the Equinox suggests that the orbital period of the Earth is not constant and therefore that it is experiencing a secular migration relative to the Sun in the current epoch.

> This paper merely presents the evidence for an acceleration of the equinox; no explanation is offered for its physical cause. Further observational data is urgently required. More meridian observers should endeavour to obtain fundamental observations of the Sun.[188]

24. GRAVITATIONAL RADIATION

Observing and studying the motion and position of the Moon in the late 17th century, Isaac Newton's friend, Edmund Halley, believed that the Moon had incurred a two-degree advance in its position as compared to the anticipated ephemeris based on eclipse records dating back over two millennia and the assumption of a constant orbital period. The cause of this "secular acceleration" was a complete mystery and the Paris Academy offered a prize for a compelling description of the phenomenon employing the universal theory of gravitation. (It was only later realized that the Moon's orbital period was increasing.) Pierre-Simon Laplace first proposed the theory of tidal dissipation based exclusively on Newtonian mechanics. The idea fit the spirit of the times, was understandable, and was accepted as the superior of the two competing theories. The mathematician, Leonhard Euler, certainly among history's foremost intellectual giants, proposed in a 1770 essay that the secular acceleration of the Moon could not be attributed to Newton's gravitational theory *per se*, but was instead caused by a kind of *resistance* of the medium through which the planets move, what was then known as the "luminiferous aether."[189] This was based on earlier work attempting to explain the secular accelerations of the Earth, the planets and comets, which were already apparent to astronomers of the time. As early as the 18th century, it was clear to Euler that the secular acceleration of the Moon was due to a differential migration rate of the Earth and Moon relative to the Sun, rather than being caused by a mutual interaction. Let the reader consider that this is the same man who discovered what is generally regarded as the most beautiful equation in all of mathematics, commonly known as *Euler's identity*. It is this supremely elegant equation that provides the underlying mathematical foundation of spacetime and temporal geometry.

$$e^{i\pi} + 1 = 0 \tag{92}$$

"De relaxatione motus planetarum" (On the running down of the motions of the planets) was originally published in Volume I of *Opuscula varii argumenti* in 1746. It was written in the scholarly Latin of the day, so an English summary appearing in the online *Euler Archive* is a welcome convenience.

> Euler reiterates that if the aether, a subtle matter that fills all of space, has a resistance, then the period times of the planets and comets and the corresponding eccentricities must become smaller; hence, the resistance of the aether should be very small. He points out that as the speed of a planet or comet is decreased by the resistance of the aether, the planet or comet is drawn nearer to the sun by the sun's force while its speed increases. But these two effects of the sun's force should force the planet or comet's distance from the sun, as well as its periodic time, to decrease. Euler also points out that his findings about how the resistance of the aether should affect the planets and comets are consistent with observations.[190]

Recall that 19th-century physicists envisioned a medium filling empty space called the luminiferous (meaning "light-bearing") *aether*, which was imagined to wave in order to propagate the energy of electromagnetic radiation. Special relativity did away with that idea in 1905; however, in 1908 Hermann Minkowski introduced the concept of the 4-dimensional spacetime fabric, which Einstein subsequently imagined as a kind of flexible medium. Einstein understood that, on a large scale, the geometry of spacetime is affected by the presence of mass-energy, which in turn produces the effects of gravity. Essentially, any metric theory of gravity such as general relativity models gravity as a kind of large-scale *wave* in spacetime. An obvious qualitative synthesis between this concept and quantum mechanics, which is based on the wave manifestation of mass-energy on the scale of photons and subatomic particles, allows for this flexible property of spacetime to be scale-independent. We may isolate this specific physical property of spacetime without regard to the smooth large-scale geometry associated with the gravitational field of a macroscopic body. So, as in general relativity, we must also allow spacetime to be a flexible medium *at the quantum scale*, which allows the spacetime geometry at this scale to be a chaotic superposition of quantum-scale waves. Consequently, we may envision *spacetime itself* as a medium for energy transport in the form of a wave moving through the spacetime fabric at the speed of light. Electromagnetic radiation can be envisioned as one possible form of spacetime wave. So, while it is certain that no medium *fills* the vacuum of space as naïvely envisioned in the past, it was premature for Einstein to abandon the concept of a "light-bearing medium" altogether in 1905. Three years later, Minkowski's spacetime fabric replaced the "aether" or 'waving medium' at all length scales.

Based on Einstein's theory, the concept of "gravitational radiation" is already envisioned as a kind of energy phenomenon manifesting as a wave in spacetime. However, LIGO and similar instruments originally designed to detect gravitational radiation as it has been previously imagined to exist have never detected the anticipated observable. This is because, like Albert Michaelson's 19th-century interferometer constructed to measure the expected aether drift, on account of incorrect physics these instruments are designed to measure something that does not actually exist. The hypothesis now being put forward is that "gravitational radiation," being a ubiquitous emission of dynamical gravitational systems, must also be *quantized*. Consequently, it manifests primarily in the microwave region of the electromagnetic spectrum rather than having some exotic (fictional) form of spacetime wave. Various tests can be performed to confirm this hypothesis, including the predicted dynamical variation in the microwave background flux as observed in the southern ecliptic hemisphere, shown in Fig. (36). Surprisingly, WMAP and similar instruments originally designed to study photons assumed to have originated with the Big Bang are functional real-time gravitational wave detectors.

Euler seems to have been essentially correct. It is apparent from empirical observation that the nature of the gravitational field is such that a small force opposes motion of a material body in the direction transverse to the gravitational gradient. This force is similar in its physical effect to mechanical friction in that it dissipates kinetic energy, although the radiation produced is non-thermal at its source. Very young stars are observed to rotate much faster than the Sun, while stars that are known to be older than the Sun have a slower rotational speed. It is virtually certain that *TGR* is responsible for this observation as well as the spin-down of pulsars, a phenomenon observed in real time. Although a number of theories have been proposed, no compelling mechanism has been established for this phenomenon.

> Pulsars associated with supernova remnants (SNRs) are valuable because they provide constraints on the mechanism(s) of pulsar spin-down. Here we discuss two SNR/pulsar associations in which the SNR age is much greater than the age of the pulsar obtained by assuming pure magnetic dipole radiation (MDR) spin-down. The PSR B1757-24/SNR G5.4-1.2 association has a minimum age of ~40 kyr from proper motion upper limits, yet the MDR timing age of the pulsar is only 16 kyr, and the newly discovered pulsar PSR J1846-0258 in the >2 kyr old SNR Kes 75 has an MDR timing age of just 0.7 kyr. These and other pulsar/SNR age discrepancies imply that the pulsar spin-down torque is not due to pure MDR, and we discuss a model for the spin-down of the pulsars similar to the ones recently proposed to explain the spin-down of soft gamma-ray repeaters and anomalous x-ray pulsars.[191]

A spinning body is a self-gravitating system whereby its own mass is constantly moving transverse to its own gravitational gradient. If transverse motion in a gravitational field causes energy dissipation leading to the secular decay of orbits, it must also cause energy dissipation leading to secular spin-down. If the dissipated kinetic energy takes the form of microwave radiation, the observed flux should depend on latitude with maximum flux measured in the equatorial plane where the tangential velocity is greatest. A suitable microwave detector in a polar or high inclination orbit can independently verify the *TGR* phenomenon, which results in peak microwave radiation brightness in the equatorial plane of a rotating astrophysical body. Three such suitable detectors that exist include the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I) in polar orbit around the Earth, the Advanced Earth Microwave Scanning Radiometer (AMSR) on-board Japan's Midori-II satellite and the RADAR instrument aboard Cassini. The proposed observation would probably require Cassini to be put in a high inclination orbit around Saturn. It may also be possible to verify from ground-based observations, perhaps even those by amateur radio astronomers, that the equatorial plane of the Moon has measurably greater microwave brightness than its polar regions. However, due to the Moon's low mass and slow rotation rate, a lunar latitudinal μ-wave flux gradient due to *TGR* may be difficult to observe.

According to the theory and evidence presented in the initial sections of this dissertation, the alleged Big Bang never occurred. Consequently, it is necessary to explain the source of the observed microwave background radiation. Just as the CMB is ubiquitous, observation of secular decrease in angular momentum of dynamical gravitational systems including spin-down of astrophysical bodies is ubiquitous. However unlikely it may seem according to conventional wisdom, empirical observation of these two phenomena suggests that they are related.

The Nobel Committee awarded the 2006 Physics Prize to George Smoot of the University of California at Berkeley and John Mather of the NASA Goddard Space Flight Center specifically "for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation." This social event lent credence to the Big Bang theory by association, particularly in the public eye. Given the revelation that empirical observations preclude the possibility of a primordial source for the CMB, it is clear that observations of the CMB were subjectively manipulated to conform with the existing paradigm, just like the reported Type Ia supernovae redshift-luminosity curve. That this did indeed occur can be surmised from review of comments made by the two investigators.

Excerpt from John Mather's Nobel Lecture:

> [nobelprize.org – video time code of *John Mather Nobel Lecture*; 20:07/34:17] [192]
> So this was the thing [the CMBR blackbody radiation curve] that people recognized as so important. And why was it so important to us? Well, I think the number one thing is that <u>people had been a little worried that the Big Bang was not the right story</u>. There were so many measurements that were a little fuzzy about what the right brightness was that not very long before, there had been measurements including measurements by our group that showed <u>there was a little bit too much radiation out here</u>. And if that were true then the whole deal was off; the Big Bang could not have been the whole story. So, I'll show you a little bit more about what this meant and how we got it.
>
> Just to tell you how we made this processing, we had to sort all the tremendous amount of data out and we had to take out something that has turned out to be a useful effect for other people. Cosmic rays hit the detector and make little bumps of temperature and though you have to find all those and take them out, then we had to make a simultaneous least squares fit, which is basically a model of the sky and a model of the instrument and <u>adjust it all to fit the data</u>. And Dale Fixsen led that team and, uh, it was a huge effort. Anyway, we make the maps. [sic]
>
> Then we take out our understanding of everything else that is going on. The sky is full of dust in between the stars and atoms and molecules between the stars, dust in the space between the planets. Um, there is some kind of far infrared background radiation from other galaxies and there is a small effect of the motion of the Earth through the Universe and <u>all of these things we have to understand and remove</u> and see if there is anything left, um, that would worry us about the Big Bang. And the answer is, uh, nothing was wrong.

Excerpt from George Smoot's Nobel Lecture:

> [nobelprize.org – video time code of *George Smoot Nobel Lecture*; 10:44/44:41] [193]
> OK, so, what's the issue for the cosmic microwave background? Basically, you are looking for a very small signal in a very large background plus the noise, that is that noise that comes from your own instrument plus the noise from, from [sic] the environment.
>
> [11:21/44:41]
> ...that meant that the signal was going to be at about a part in ten to the minus six compared to the background radiation that is coming in and so this is the beach party that is going on and you are trying to hear a whisper back of the hall here. And so we had to come up with techniques in order to do that and so the technique is to compare the signal with signals of the same level and what the improvements in the field had been is how to do that and how to improve on that and FIRAS was an extreme example of that. And so you either look at something that is the same temperature as the microwave background or you do what we did, compare one part of the microwave background with another. And the other thing you have to do is <u>exclude, reject, average out other signals and sources and that is why the data analysis is so complicated and why it took so long</u>, took such a good team. So if it's easy, try to read it now.
> (George points to an image of the WMAP Internal Linear Combination Map and laughs.)
>
> [30:05/44:41] Title of slide shown: *COBE Spectrum of the Universe, <u>First 9 minutes of data</u>*
>
> And this is sort of the spectrum, you'll notice with four hundred times error bars. This we presented results from COBE at the 1990 AAS meeting. John got up and talked before me, and at the end he presented the spectrum. At the end he got a standing ovation, which is one of the few things I've ever, I've ever time, I've ever seen that [sic]. Everybody appreciated how, um, impressive it was.

> [31:00/44:41]
> Here is the intensity plot. You can still see the FIRAS curve on here and it just looks like a straight line until you get to the very highest frequency and you see a slight distortion and you see the UBC measurement and see how both of them were very good, but the FIRAS measurement is extraordinary. I mean it really just tied things down, uh, in a very good way and <u>you know, now I'm sort of embarrassed because these points don't exactly line up, but, they, they're within errors, I guess...</u> And so we turn to COBE and talk about the differential microwave radiometer.
>
> [35:56/44:41]
> Eventually we made these maps. I believe these are the two-year or four-year. I forgot the color scheme. You see the dipole, now in galactic coordinates. Here is the galactic plane, looking down the spiral arm one way, the other spiral arm the other way, and then blown up with the dipole removed. You see the variations off the plane, the galaxy showing very dominant, the galaxy masked off.
>
> These are the things we believe are the original, uhh, intrinsic perturbations of the Universe that are reflected in the light coming from the distant Universe. And, we continued on, at the same time we are taking more data with COBE we are doing balloon flights. Here are some pictures from MAXIMA and BOOMERanG of what the sky looked like, and if you looked at the COBE, original COBE map, you will see that you see variations where a bunch of cool areas are collected together and a bunch of warm areas are collected together and that's what you get if you have long waves with small waves superposed on it. If you have a dip and you have wherever there is a dip below it you see a bunch of cool spots and when it goes back warm, you don't see the variations. But likewise on a warm spot, and you have variations, you see the little peaks on it. So you, if you really were good and can do transforms with your eyes, you'd recognize this is a scale invariant spectrum, but when you go and look at the MAXIMA and the, uh the, BOOMERanG max you see a particular scale is picked out. And this is the beginning of not only seeing that there was a primordial perturbations but that there were process, some in the early Universe. [sic]
>
> Beginning to understand what is going on in the Universe.

Actually, there is no possibility of anyone having had an accurate idea about what is going on in the Universe without understanding geometric cosmic time. The COBE and WMAP teams were focused on proving their *a priori* assumption that the Big Bang did indeed occur. They clearly did not consider that there was even a possibility that the Big Bang theory was incorrect, so they consciously discarded some of the most important information about the cosmic microwave radiation gathered by their instruments as being irrelevant to cosmology. — What property of a photon can one examine to definitively identify that it is a 'Big Bang photon'? Other than an idea handed down by a series of academic authorities, what observable and testable property today makes a 'Big Bang photon' fundamentally different and special from other photons? *Nothing*. The only thing that distinguishes such a photon from another is arbitrary *faith* in what has always been a tenuous if not unreasonable scientific theory. That theory is based on the assumption that the observed progressive redshift of distant galaxies implies a general expansion and that no possible alternate phenomenon of nature might be found to explain it. That assumption has now been definitively debunked. Moreover, observation of ubiquitous energy dissipation in dynamical gravitational systems (*TGR*) implies a real-time source for the observed CMB.

25. THE ABUNDANCE OF THE LIGHT ELEMENTS

Upon initial formation by gravitational collapse of a large mass of interstellar gas, all stars begin to generate energy by a process of nuclear fusion whereby hydrogen is converted into helium. It is currently understood that stars that are less than about 1.4 times the size of the Sun with lower core temperatures employ a slower fusion chain reaction. Larger stars, with higher core temperatures, employ a much faster chain reaction and though they may have a much bigger fuel supply, they consume their hydrogen fuel much faster and are much shorter lived than smaller stars.[194] — The solar wind has been measured by count to be approximately 95% protons (H+), 4% alpha particles (He++) and 1% minor ions, of which carbon, nitrogen, oxygen, neon, magnesium, silicon and iron are most abundant.[195] In contrast, spectroscopy of the Sun indicates a relative abundance by weight of ~70.6% hydrogen, ~27.5% helium, ~1.0% oxygen, ~0.3% Carbon, ~0.2% Neon ~0.1% Iron, with the remaining ~0.3% composed of about

sixty additional trace elements.[196] Looking out at the Universe, we see in the most general terms that it is made up mostly of hydrogen (H) atoms with a single proton in the nucleus and for about every ten of these there is one helium (He) atom with two protons and two neutrons in the nucleus. Depending on where we choose to look, the Universe seems to be generally somewhere in the neighborhood of 70-75% H and 23-28% He by weight with only 2% attributable to all of the other elements combined.

If we presuppose that the Universe is only on the order of about fourteen billion years old according to 20^{th}-century ideas, then there is not enough time for the observed amount of helium to have been synthesized in the stars. However, this so-called "helium problem" is of lesser concern if this age constraint is removed. Although it has been argued otherwise, a remaining problem that arguably cannot be elegantly removed by allowing for more time is the observation of trace amounts of naturally occurring deuterium or "heavy hydrogen" (^{2}H) and other light element isotopes including helium-3 and lithium-7 (^{3}He, ^{7}Li).[197] A very high temperature plasma (~10^9 K or ~0.1 Mev) of free protons and neutrons ($p + n$) that cools rapidly is understood to be a process that leads to the nucleosynthesis of the light elements.[198] The high temperatures required for the required reaction sequences to take place are not found in stars and deuterium production requires an environment of high energy coupled with low density.[199] The observed existence of the light elements cannot be due to normal processes in stellar evolution, particularly because typical stellar evolution involves destruction of deuterium.

In 1920, Arthur Eddington pioneered the revolutionary idea that stars create energy by thermonuclear fusion of hydrogen into helium. Later, George Gamow was primarily concerned in the late 1940s with the problem of nucleosynthesis.[200] A 1948 article in *Nature* summarized ideas presented in three previous papers that year in *Physical Review*.[201] The precision science of nucleosynthesis is independent of assumptions concerning the environment in which it takes place. It became immediately apparent that in their nuclear reactions, stars typically consume rather than produce deuterium, so where did the deuterium that we observe come from? The idea that a very high temperature is needed that is clearly not available in any stars, combined with the idea that the galaxies seemed to be expanding from a common point in space and time, implied that the only natural occurrence of the necessary plasma temperatures was a very dense and hot "primeval fireball" that started the Universe. Development of the modern view of primordial nucleosynthesis is described in *Schramm and Wagoner* (1977).[202] The nuclear reactions of very high temperature plasmas are now relatively well understood, yet over half a century after George Gamow initiated the investigation of Big Bang nucleosynthesis there is still considerable ongoing debate as to how the observed abundances occurred.

> A significant discrepancy between the calculated ^{7}Li abundance deduced from WMAP and the Spite plateau is clearly revealed. To explain this discrepancy, three possibilities are invoked: systematic uncertainties on the Li abundance, surface alteration of Li in the course of stellar evolution, or poor knowledge of the reaction rates related to ^{7}Be destruction. In particular, the possible role of the up to now neglected ^{7}Be (d, p) 2α and ^{7}Be (d, α) ^{5}Li reactions is considered. Another way to reconcile these results coming from different horizons consists of invoking new, speculative primordial physics that could modify the nucleosynthesis emerging from the big bang and perhaps the CMB physics itself.[203]

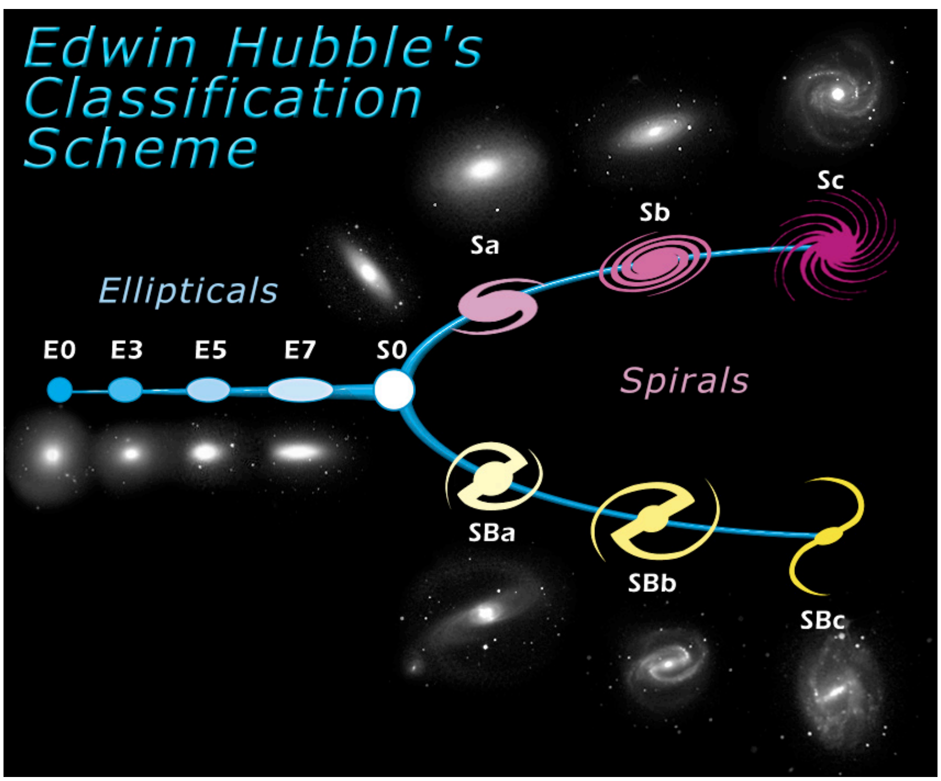
> Other than the blackbody spectrum of the microwave background, there is very little evidence in support of the nearly universally accepted hot Big Bang model of cosmology–the "standard" model. Primordial nucleosynthesis provides a unique opportunity to test the assumptions of the standard model, serving as it does, as a probe of the physical conditions during epochs in the early evolution of the Universe that would otherwise be completely hidden from our scrutiny.[204]

> We consider inhomogeneous big bang nucleosynthesis in light of the present observational situation. Different observations of ^{4}He and D disagree with each other, and depending on which set of observations one uses, the estimated primordial ^{4}He corresponds to a lower baryon density in standard big bang nucleosynthesis than what one gets from deuterium. Recent Kamiokande results rule out a favorite particle physics solution to this tension between ^{4}He and D.[205]

Currently, it is generally held that there is no alternative to Gamow's hot primeval fireball for synthesizing deuterium, but we shall find that this is not the case according to observational evidence. George Gamow's ideas concerning the source of the temperature requirements of nucleosynthesis germinated more than a decade before Thomas Matthews and Alan Sandage discovered "radio stars," now called quasi-stellar objects (QSO) or more familiarly "quasars," which are currently understood to be a subset of active galactic nuclei (AGN).[206] In 1962, Martin Schmidt obtained a spectrum of object 3C 273 (object #273 in the 3rd Cambridge Catalogue) and found it to have a $z = 0.158$ redshift. Given its observed linear flux of about $29{\times}10^{-14}$ *ergs cm*$^{-2}$, this implied an intrinsic luminosity far greater that of the entire Milky Way Galaxy.[207,208] Even if the distance to this object is less than originally estimated, its intrinsic luminosity is still inexplicable in the context of conventional physics. AGN, some of which are associated with enormous relativistic mass outflows from a small volume of space, typically observed in the form of long thin jets, have qualities one would expect for natural sources of temperatures high enough to meet Gamow's nucleosynthesis needs, but in 1948 he knew nothing about them. The required correction to the general theory of relativity proposed earlier must change our ideas concerning the nature of active galactic nuclei. This will be discussed in the following section together with the most recent observational evidence, which indicates that some AGN are associated with deuterium production.

26. GALAXY EVOLUTION AND MORPHOLOGY

Speculation on the life cycle of galaxies began in 1926 when Edwin Hubble put forward his famous "tuning fork" diagram including the explicit proposition that galaxy evolution takes place starting from "early types" on the left of the diagram and evolving to "late types" on the right. A clear distinction was drawn between two apparent evolutionary paths in the creation of spirals, those exhibiting a bar through their center (SB-type) and those that do not (S-type).



Courtesy NASA and STSci [209]

Figure 70 | Hubble "tuning fork" diagram. Modern observations imply that Hubble's assumption of a left-to-right evolutionary sequence is precisely the opposite of reality.

Modern observational evidence implies that Hubble's idea that "late-type" spiral galaxies evolve from "early-type" ellipticals is precisely the opposite of the actual galactic evolutionary sequence. It is now well known that spiral galaxies exhibit profuse amounts of gas and dust with the characteristic arms harboring stellar nurseries of active new star formation. In contrast, elliptical galaxies have a characteristic paucity of gas and dust and spectroscopic studies indicate a more mature system with minimal new star formation. Giant cluster-dominating (cD) elliptical galaxies, which may exhibit multiple galactic nuclei, are typically found at the centroid of rich galaxy clusters, surrounded by smaller ellipticals and a halo of outlying spiral galaxies. Size, morphology and stellar velocity profiles strongly suggest that smaller elliptical galaxies have typically formed over a long time from the merger of spiral galaxies while larger elliptical galaxies are a conglomerate of smaller elliptical galaxies.

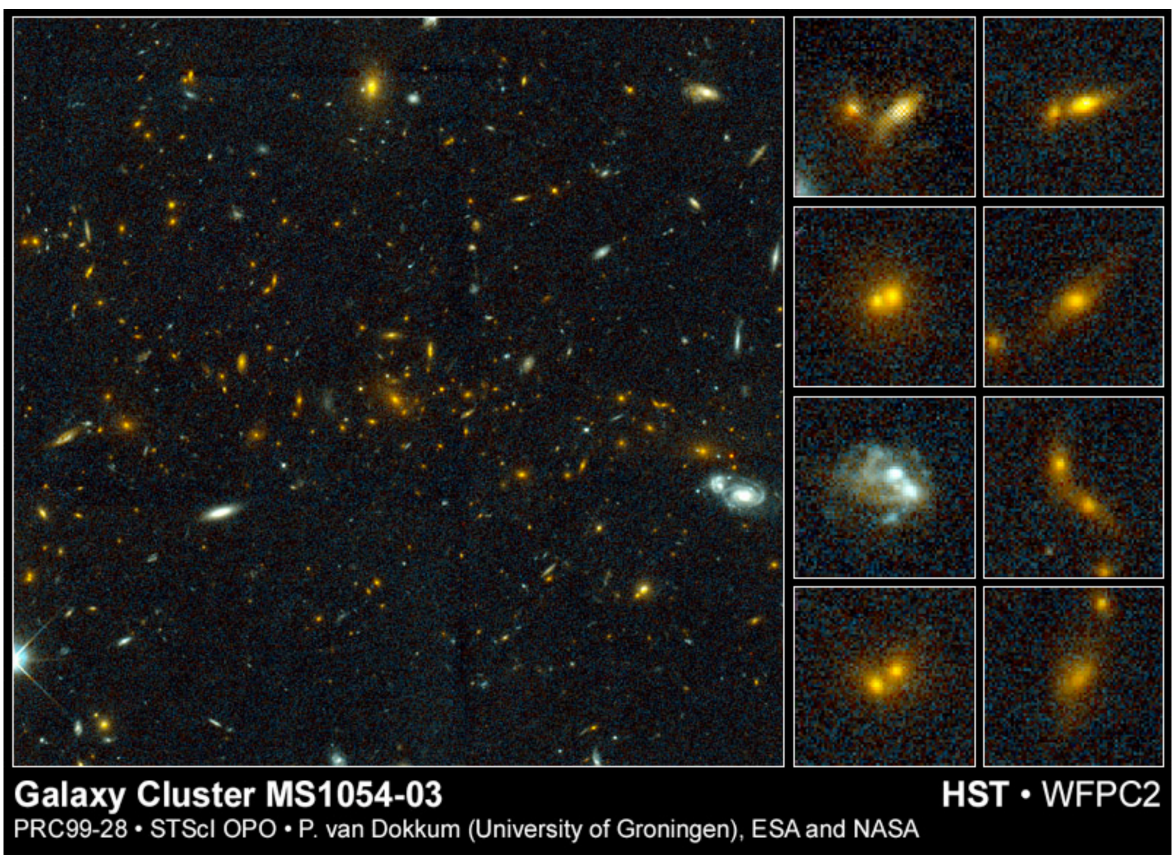
The current state of observational astronomy, which has benefited from late 20th-century advances, implies that galaxy evolution and morphology is radically different and considerably more complex than Hubble imagined. The spiral arms of barred galaxies typically emanate from the ends of the bar and most spiral galaxies exhibit some of the characteristics of the barred variety with the SB-types merely representing the extreme examples, so Hubble's broad distinction between the two morphologies is almost certainly incorrect. Based on Doppler data, the average rotation period for a spiral galaxy is quite short relative to the age of its constituent stars (e.g., the Sun's galactic rotation period is estimated to be about 250 million years or about 5% of its estimated current age). Therefore, many rotations must have occurred for a mature spiral galaxy. Contrary to intuition, the spiral arms do not wind up commensurately with the observed differential rotation of the inner and the outer regions. The spiral arms are currently understood to manifest due to the systematic radial change in the orientation of elliptical galactic orbits of stars and gas. This creates natural spiral-shaped density waves, creating periodic enhancements in the background stellar distribution and regions of enhanced star formation. Galaxies with conspicuous central bulges tend to have more tightly wound spiral arms; the "earlier" the stage, according to Hubble's system, the larger the bulge fraction (the fraction of galactic light sourced from its bulge).[210] With very rare exception, the spiral arms are trailing, i.e., stellar orbits are clockwise in Fig. (71).

Courtesy NASA and STSci [211]

Figure 71 | NGC 1300, a barred spiral galaxy at $z \approx 0.0053$

Courtesy NASA and STScI [212]

Figure 72 | Pending merger of two spiral galaxies (NGC 2207 and IC 2163) at $z \approx 0.0091$



Courtesy NASA & STScI [213]

Figure 73 | Ancient galaxy mergers observed within a large distant cluster ($z > 0.8$)

The morphological type of a galaxy is clearly associated with the density of the region within which it is found. Galaxies in clusters are far more likely to be ellipticals or of type SO and observations are consistent with there being essentially no spiral galaxies in the cores of regular clusters. A galaxy's radius within a cluster is the primary factor that dictates its morphology. Moreover, there is a correlation between the morphology of the cluster and the morphology of its constituent galaxies; the higher the percentage of ellipticals in a cluster, the more symmetrical the cluster is observed to be. This very strongly suggests that elliptical galaxies are in general intrinsically older than spiral galaxies, that larger ellipticals formed by multiple mergers are older still than smaller ellipticals and that more symmetric galaxy clusters are older than those clusters that have a more haphazard architecture.

The Big Bang paradigm suggested that galaxies originally all formed at approximately the same time from the gravitational collapse of protogalactic masses of hydrogen gas. There are so many confrontations between this idea and empirical observations, as well as basic theoretical considerations, that it is difficult to believe that it was seriously considered for so many decades. Primarily, the idea cannot explain the various structures observed that cover the scale extending from globular clusters of stars in galactic halos to enormous superclusters that tie together numerous smaller clusters of many galaxies. The huge variation in the intrinsic ages of these structures based on dependency relationships is immediately apparent: elliptical galaxies are formed by the merger of old fully-formed spiral galaxies, elliptical galaxies merge to form still more massive ellipticals, jagged clusters become symmetric over eons, etc. However, the social and intellectual blinders of the dominant paradigm were so overwhelming during the 20th century that all of the empirical evidence against the Big Bang theory was essentially disregarded.

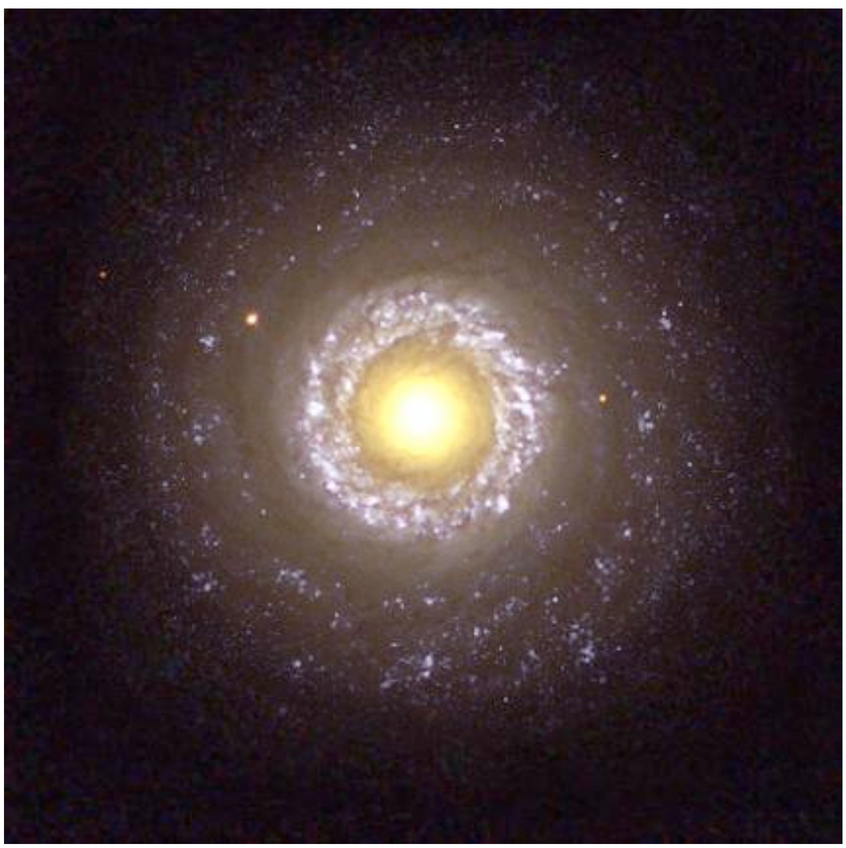
Courtesy NASA, STScI/AURA[214]

Figure 74 | Dramatic view of the spiral galaxy M104 at $z \approx 0.0034$

Observational astronomy has made it quite clear at this point that younger galaxies are typically spirals with a characteristic flat disk. How do these disks form? An answer arises based on what we see. Similarly, the historical fact of continental drift is rather obvious when one considers that the continents of Africa and South America quite clearly fit together at some time in the past. — It seems quite certain that jets of effluent matter emanating from a typical active galactic nucleus build the plane disks of spiral galaxies from the inside out. As we shall soon see in the next section, there is a relationship between galactic black holes, which consume old galaxies, and galactic white holes, which create new galaxies.

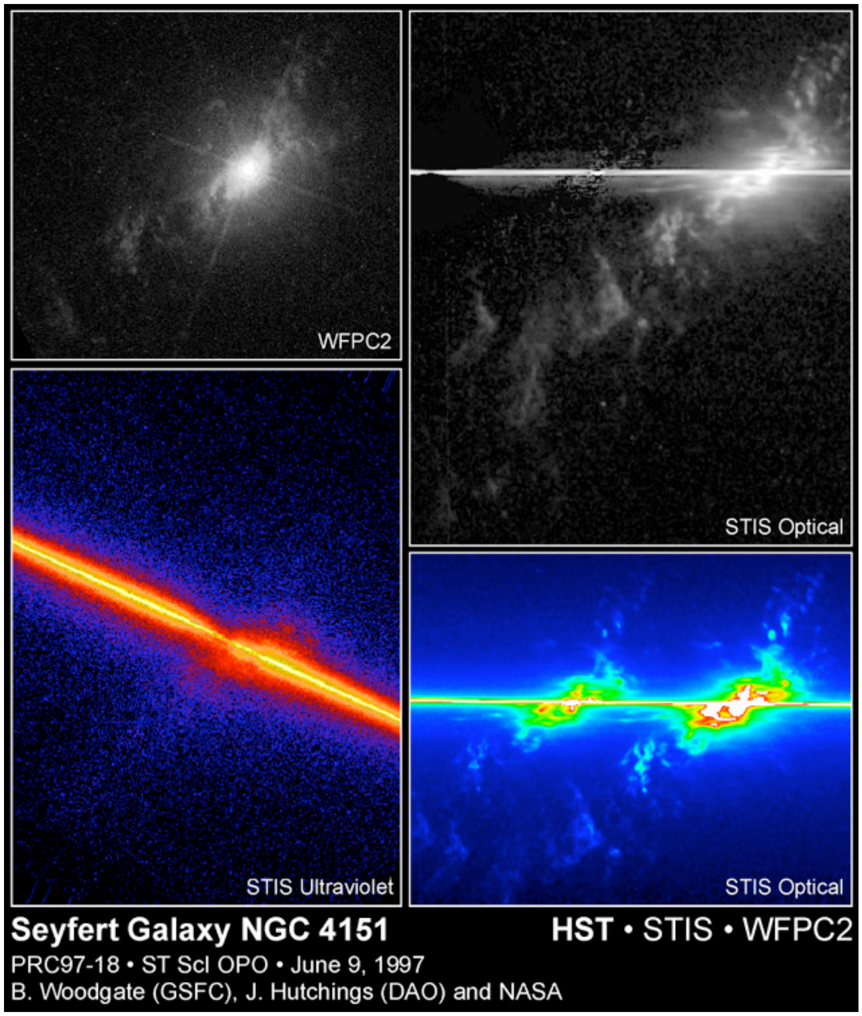
These disks were most certainly not formed by gravitational collapse of a hydrogen gas cloud, first because there never was a Big Bang and second because gravitational collapse tends to create spherically shaped things such as stars and planets, not flat disks. However, jets in a plane from a central source will quite naturally create a self-gravitating rotating plane disk of matter over time and we know that such effluent jets exist because we see them. What must be relatively new youthful galaxies, as they are generally associated with massive star formation, are commonly observed in the local Universe. They are called Seyfert galaxies and make up about two to three percent of the local galaxy population.[215, 216] Moreover, we see these same nascent galaxies all over the Universe. Typical quasars are just distant AGN similar to the local variety that have been misinterpreted to be a distinct class of object orders of magnitude brighter than they are in reality due to a faulty redshift-distance scale.

> We argue that the narrow-line regions (NLRs) of Seyfert galaxies are powered by the transport of energy and momentum by the radio-emitting jets. This implies that the ratio of the radio power to jet energy flux is much smaller than is usually assumed for radio galaxies. This can be partially attributed to the smaller ages of Seyferts compared to radio galaxies, but one also requires that either the magnetic energy density is more than 1 order of magnitude below the equipartition value or, more likely, that the internal energy densities of Seyfert jets are dominated by thermal plasma, as distinct from the situation in radio galaxy jets where the jet plasma is generally taken to be nonthermally dominated. If one assumes that the internal energy densities of Seyfert jets are initially dominated by relativistic plasma, then an analysis of the data on jets in five Seyfert galaxies shows that all but one of these would have mildly relativistic jet velocities near 100 pc in order to power the respective narrow-line regions. However, observations of jet-cloud interactions in the NLR provide additional information on jet velocities and composition via the momentum budget.[217]



Courtesy NASA, STScI/AURA [218]

Figure 75 | Seyfert galaxy NGC 7742 at $z \approx 0.0055$



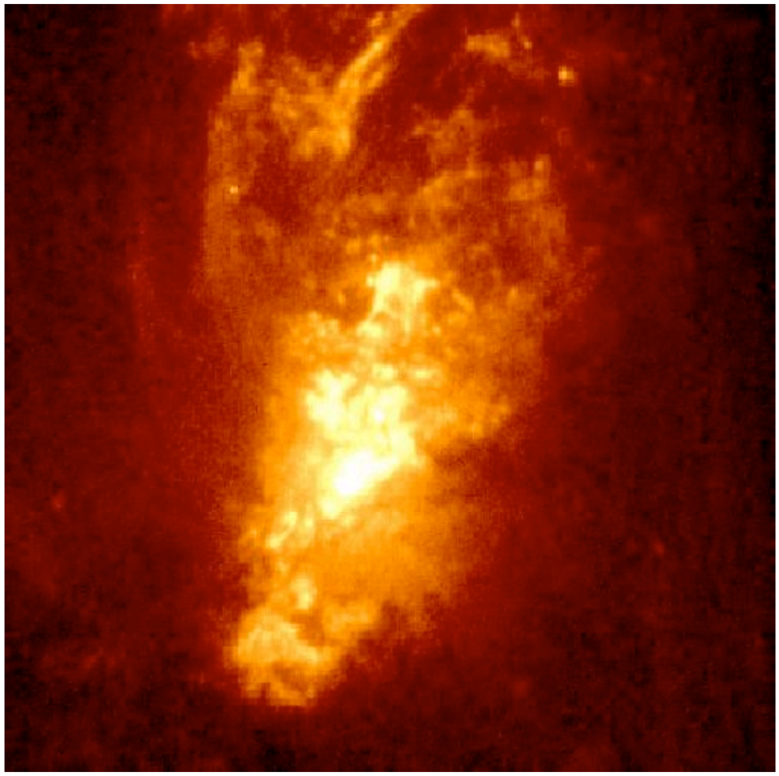
Courtesy NASA, STScI/AURA [219]

Figure 76 | Core of Seyfert galaxy NGC 4251 at $z \approx 0.0036$

The *Hubblesite* caption to Fig. (76) follows.

> The Hubble telescope's imaging spectrograph simultaneously records, in unprecedented detail, the velocities of hundreds of gas knots streaming at hundreds of thousands of miles per hour from the nucleus of NGC 4151, thought to house a super-massive black hole. This is the first time the velocity structure in the heart of this object, or similar objects, has been mapped so vividly this close to its central black hole.
>
> The heart of NGC 4151 was captured in visible light in the upper left picture. In the other images, Hubble's imaging spectrograph has zeroed in on the galaxy's active central region. The Hubble data clearly show that the some material in the galaxy's hub is rapidly moving towards us, while other matter is rapidly receding from us. This information is strong evidence for the existence of a black hole, an extremely compact, dense object that feeds on material swirling around it.[220]

It is not a black hole consuming mass-energy that astronomers are looking at in the heart of Seyfert galaxies; it is a *white hole* that is ejecting enormous amounts of matter and literally building this spiral galaxy from the inside out. However, without the required correction to Einstein's gravitational theory, white holes did not exist in the minds of astrophysicists and astronomers even though they have been observing the rather obvious white hole signature property of massive *efflux* for a number of decades.



Courtesy NASA, ESA & STScI [221]

Figure 77 | Core of Seyfert galaxy NGC 1068 at $z \approx 0.0038$

> A representative sample of 12 extended quasars from the 3CR catalog has been imaged at 4.9 GHz using the VLA [Very large Array]. … Jets are detected on at least one side of every source. The jets are well collimated compared with those in less powerful sources, but spreading is detected in most of them. The opening angles of several jets are not constant, but show recollimation after an initial regime of rapid spreading. … The correlations between the prominence and sidedness of the large-scale straight jet segments and of the small-scale central features favor models in which kiloparsec-scale jets initially have bulk relativistic velocities. [222]

As discussed previously, the nucleosynthesis of deuterium and other light elements requires a very high temperature, exceeding that found even at the core of large stars. Moreover, this initially very hot and dense plasma must cool rapidly in a low-density environment. Rapid free expansion of a high-pressure jet is an excellent way to achieve such cooling. A jet or jets of effluent matter from a central white hole is also a natural means, and arguably the only realistic means, of creating an *isolated* rotating disk of gas and dust in space. A conclusion one may draw from this scenario is that the disk, and in particular its center, will exhibit an inexplicably high concentration of deuterium and other light elements, including a high percentage of helium. That evidence comes from our own galaxy.

> The Galactic Centre is the most active and heavily processed region of the Milky Way, so it can be used as a stringent test for the abundance of deuterium… As deuterium [D] is destroyed in stellar interiors, chemical evolution models predict that its Galactic Centre abundance relative to hydrogen is D/H = 5×10^{-12}, unless there is a continuous source of deuterium from relatively primordial (low-metallicity) gas. Here we report the detection of deuterium (in the molecule DCN) in a molecular cloud only 10 parsecs from the Galactic Centre. Our data, when combined with a model of molecular abundances, indicate that D/H = $(1.7\pm0.3)\times10^{-6}$, five orders of magnitude larger than the predictions of evolutionary models with no continuous source of deuterium. The most probable explanation is recent infall of relatively unprocessed metal-poor gas into the Galactic Centre (at the rate inferred by Wakker). Our measured D/H is nine times less than the local interstellar value, and the lowest D/H observed in the Galaxy. …

> The Galactic Centre … has a higher abundance of elements heavier than He (metallicity), faster star formation rate, and steeper initial mass function. Thus the astration (recycling) rate in the Galactic Centre should be considerably larger than elsewhere in the Galaxy, resulting in a reduced D abundance. Chemical models at 12 Gyr of the Galactic bulge and the Galactic Centre predict the almost total destruction of deuterium giving D/H = 3.2×10^{-11} and D/H = 5×10^{-12}, respectively. Thus if there were no additional sources of D, the Galactic Centre molecular clouds should be composed primarily of astrated material completely depleted in D, and DCN should not be detectable. Thus the mere detection of D (in DCN) in the Sagittarius A molecular clouds requires a continuous source of deuterium to negate the effects of astration. Alternatively, if D is produced by any stellar or Galactic process, then it should be more abundant in the Galactic Centre and there should be a corresponding gradient in the D abundance.[223]

In contrast to prior conventional explanations for these observations, we may conclude that the original source of the deuterium and other light elements observed in the Milky Way was its historical active galactic nucleus characterized by rapidly expanding and cooling jets of material. This phase of its evolution occurred long ago and significantly higher astration in the region of the core has caused the observed radial gradient. Additional corroborating evidence for this idea is found in observations of quasar (distant Seyfert AGN) radiation. As distance can no longer be associated with conventional intrinsic "lookback time," these observations take on new meaning. "Primordial" has only local meaning, and certainly has no meaning in a cosmological context.

27. COSMIC DYNAMICAL STABILITY

If the Cosmological Principle is "perfect" such that the large-scale Universe is homogeneous, isotropic and has been in dynamic equilibrium for eternity, the question arises as to how cosmic gravitational collapse is prevented over an arbitrarily large time scale. The answer is intuitive and beautiful.

In 1935 Einstein and his long-time collaborator Nathan Rosen published a paper based in large part on the work done by Karl Schwarzschild in which they showed that the Schwarzschild *singularity* at $r = 0$ could not exist and that implicit in the general relativity formalism is a curved spacetime structure that can join two distant regions of spacetime through a tunnel-like spatial shortcut.[224] However, in a 1962 paper, Robert Fuller and John Wheeler showed that according to the Einstein field equations "The key point in preventing any violation of causality is simple: The (Schwarzschild) throat of the wormhole pinches off in a finite time and traps the signal in a region of infinite curvature."[225] Lacking awareness of Einstein's initial blunder in developing GR and the simple concept of geometric time, Einstein and Rosen's intuitive idea of a physical wormhole or "Einstein-Rosen Bridge" was subsequently abandoned.

Minkowski showed that the Lorentz transformation equations require space and time to be orthogonal. It is then an almost trivial step to model the local time coordinate as the local vertical for any region of spacetime. The concept of geometric time implies that spacetime is smooth and continuous everywhere. There is no such thing as a physical singularity and "infinite curvature" is a meaningless term. A black hole is not an *object*; rather, it is a *process* caused by catastrophic gravitational collapse, which creates an unstable spacetime geometry condition. The local 'hole' in spacetime can only be maintained if it is fed by a continuous flow of mass-energy. The direction of the initially established momentum, which is caused by a local catastrophic gravitational collapse, determines which side of the hole is "black" and which side is "white." If no such external energy source exists, the hole immediately ceases to exist; spacetime reverts to its normal geometry.

Traveling through the wormhole, time changes direction in the four-dimensional spacetime "world" from one end to the other, but from the point of view of a particle free-falling through the wormhole and experiencing enormous gravitational tidal forces, time is always advancing perfectly normally. It should be understood that proper time does not ever "reverse" anywhere; it just changes direction across the ends of the wormhole in reference to a global coordinate system for the four-dimensional spacetime "world." This is similar to how the gravitational gradient changes direction from one side of a planet to another. Spacetime is smooth and continuous everywhere over this "shortcut" connecting opposite sides of the spacetime Universe; *no physical singularity exists*. There is no fundamental difference in interpretation between the minimum diameter inside the hole at what is called the hole's "horizon" and the local vertical to the sphere outside the hole; both represent local proper time at their respective locations.

What is unique about the hole is that a large volume of unrestricted space has funneled down to a rather small volume of restricted space at the "horizon" located at the minimum diameter at the core, so that whatever goes through the hole must pass through a region of extreme pressure and temperature. When we imagine mass-energy traveling through the hole shown in Fig. (78), we must restrict it to being on the *surface* of the hole in the diagram, which represents space, not the interior volume of this hole, which does not represent physical space. The hole's surface abstractly represents a three-dimensional volume in four-dimensional spacetime, so jumping up one dimension we can imagine matter accelerating through an increasingly restricted volume of space like water from a hydrant being forced through a fire hose nozzle. The only exceptionally unusual physical features of the hole as compared to the normal Universe are huge gravitational tidal force that rip matter apart and tremendous compression at the throat of the hole, causing uniquely high temperatures there that are not found even at the centers of very large stars.

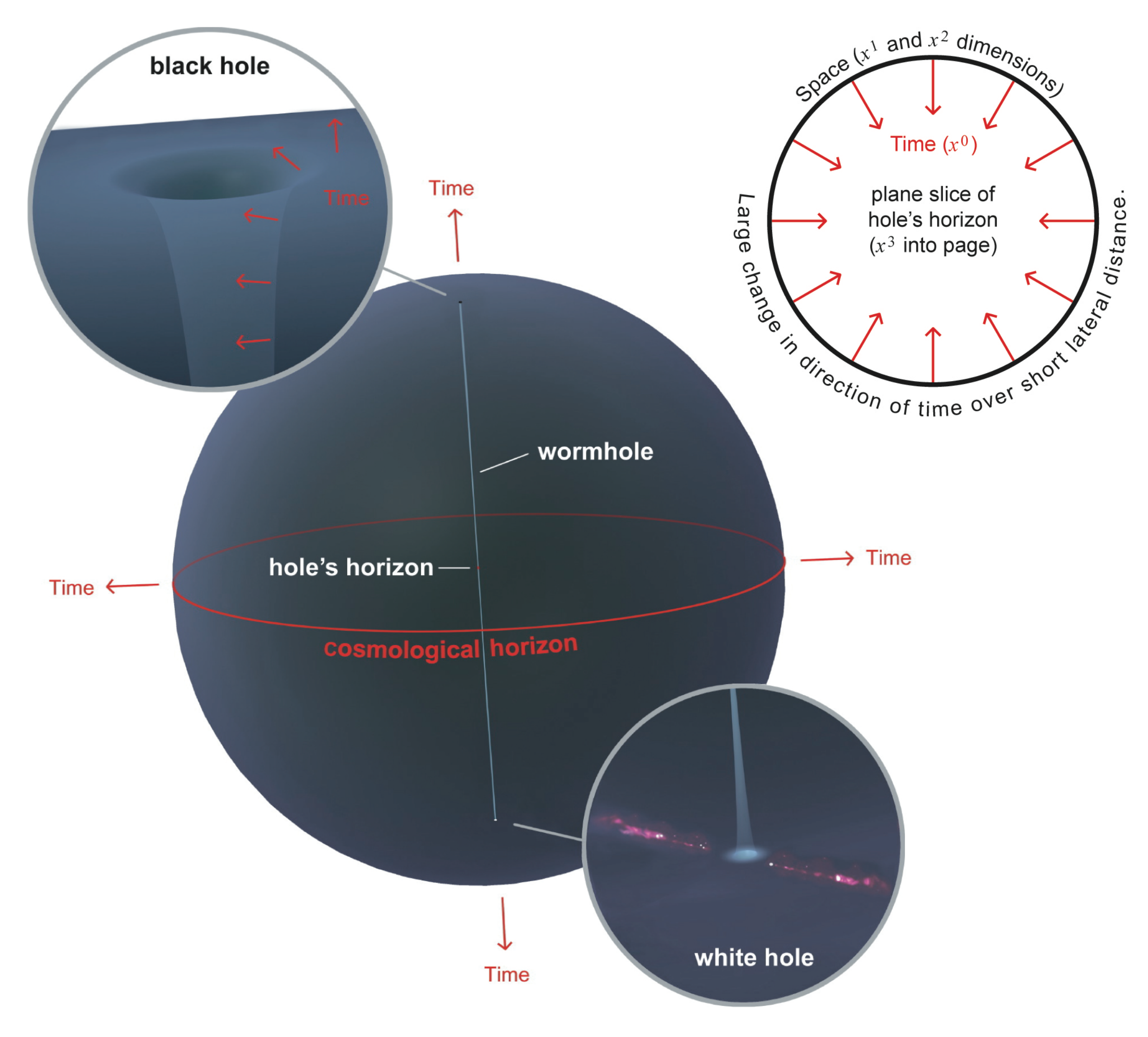


Figure 78 | Conceptual model of a wormhole. Conventional relativistic physics, which does not recognize cosmic temporal geometry, models a black hole as a local *object* having a characteristic local mass (i.e., the hole would be represented by a single point on the surface of this cosmic map). Aptly named, but improperly modeled in the 20th century, a black hole is in fact the entrance to a spatial bridge providing a flow of mass-energy between two cosmic antipodal regions of spacetime.

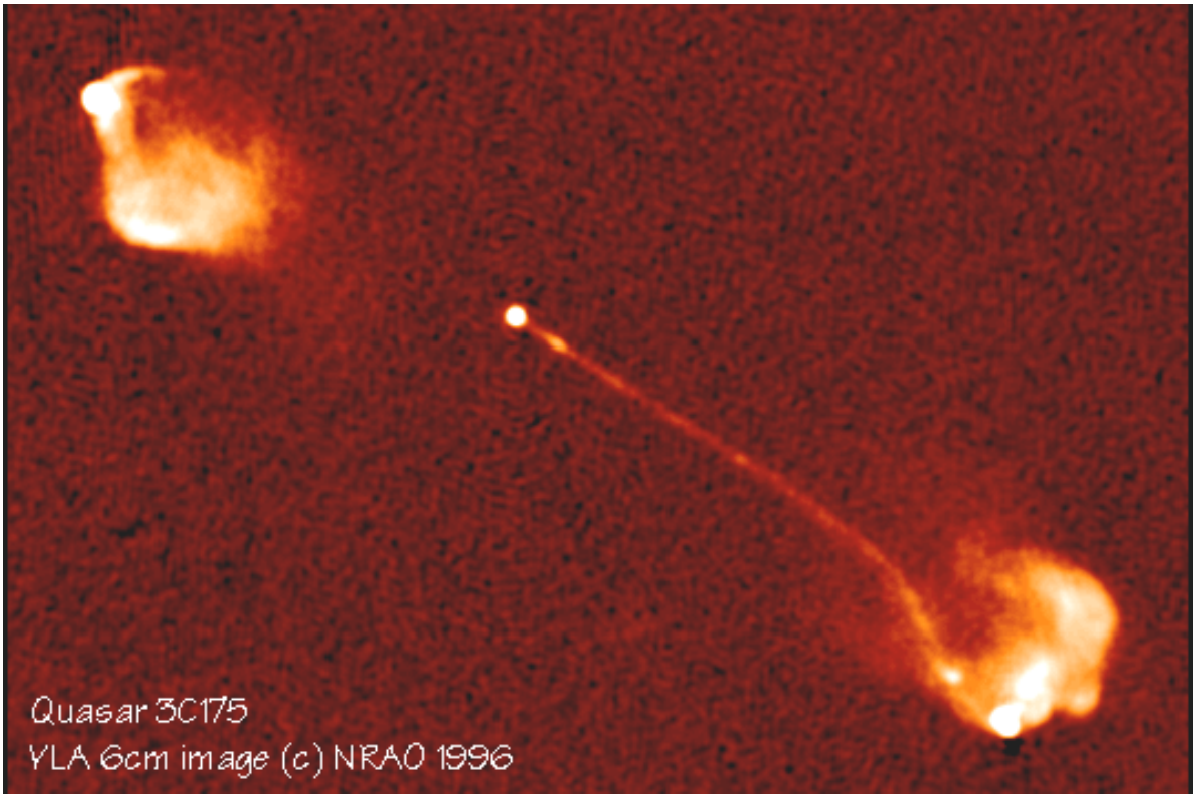
The idea that time changes direction in spacetime across the ends of the wormhole connecting cosmic antipodes might seem peculiar and so warrants some discussion. — Imagine two people, Jocelyn and Vera, standing about 20,000 kilometers apart on opposite sides of the Earth. Jocelyn drops something, perhaps a set of keys, and Vera does the same thing. Is it not true that in global coordinates, Jocelyn's 'up' is Vera's 'down' and Jocelyn's 'down' is Vera's 'up'? Certainly, but does this imply anything unusual? Does this mean that Vera's 'up' somehow represents a *loss* of energy relative to Jocelyn rather than a gain? No, it implies nothing special or peculiar. Similarly, as concerns a cosmological map there is nothing strange about the fact that antipodal local time coordinates point in different directions in cosmic spacetime coordinates. However, the change in direction of time across the hole is what fundamentally makes the wormhole "bridge" through spacetime work. Note that at the minimum radius throat of the wormhole, which is the true nature of a black hole's horizon, the time and space coordinates are swapped with those just outside the entrance and exit to the hole. It is senseless to think of a material object "falling" off the surface toward the axis of symmetry because the diameter of the hole at the horizon represents a time coordinate, not a space coordinate over which material objects can translate. Motion of mass-energy through the wormhole is restricted to the curved *surface* of the diagram.

Nature always seeks balance. Heat flows from a hot object to a cold object until both are in thermal equilibrium. An electric field causes electric charge to flow across the potential in an attempt to create charge equilibrium. In this case, we have an imbalance with a natural tendency for mass-energy to flow across the hole from a region of higher mass-energy density to a region of lower mass-energy density. One may quite accurately envision the wormhole as something very much like a combination of an extremely powerful linear accelerator and a jet engine. The efflux typically forms a relativistic jet of material emitted from an active galactic nucleus that is by physical necessity located on the opposite side of the Universe from the maw of the black hole at the core of a large galaxy that feeds it. An important idea is that this spacetime configuration is fundamentally unstable. It takes mass-energy *flow* through the hole to maintain it. Without such an energy flow, spacetime will not maintain this unnatural geometric configuration, but rather will revert to its normal geometry, thus destroying the hole. When a large isolated star goes supernova, it will generally implode into a short-lived wormhole. Some part of the star's mass creates the hole and moves through it. The supernova occurs on one side of the hole. On the other side of the temporary wormhole, a gamma ray burst (GRB) is observed, but the two events take place on opposite sides of the Universe. Wormholes transport mass energy from one side of the Universe to the other side. Energy is conserved on a cosmological scale, but at the location of the black hole there is a local net decrease in mass energy over time, and at the location of the white hole there is a local net increase in mass energy over time.

There will naturally be variability in the amount of mass-energy feeding a black hole at the center of a galaxy per unit time. Sometimes more energy will enter the hole and sometimes less. This will cause commensurate fluctuations on small timescales in the observed luminosity of the remote corresponding white hole. Thus, AGN are observed to fluctuate in brightness over surprisingly short time spans. A black hole and its corresponding white hole cannot be observed simultaneously. Of two such connected objects, one can see at most either the energy source outflow or the energy sink inflow; it is impossible to see both simultaneously for they are on opposite sides of a cosmological redshift horizon. If either one is near the observer's cosmological redshift horizon, then so is the other; consequently neither would be visible.

Fig. (79) is an image in the radio spectrum produced by Alan Bridle of the National Radio Astronomy Observatory (NARO). An accurate and intuitive description of this startling image appears on NASA's "Astronomy Picture of the Day" Web site. Alan Bridle's Webpage, "Images of Radio Galaxies and Quasars," shows additional remarkable images of AGN jets: http://www.cv.nrao.edu/~abridle/images.htm

> 3C175 is not only a quasar, it is a galaxy-fueled particle cannon. Visible as the central dot is quasar 3C175, the active center of a galaxy so distant that the light we see from it was emitted when the Earth was just forming. The above image was recorded in radio waves by an array of house-sized telescopes called the Very Large Array (VLA). Shooting out from 3C175 is a thin jet of protons and electrons traveling near the speed of light that is over one million light-years long. The jet acts like a particle cannon and bores through gas cloud in its path. How this jet forms and why it is so narrow remain topics of current research.[226]



Courtesy NRAO/AUI/NSF[227]

Figure 79 | Radio telescope image of a distant quasar.

Gamma-ray bursts are isotropically distributed sudden intense flashes of high-energy gamma rays sourced at cosmological distances that are observed to occur regularly about once per day. They were first reported publicly in 1973 based on earlier initial detections that took place by the U.S. Vela military satellites designed to monitor the Nuclear Test Ban Treaty. Launched in 1991, the Burst and Transient Source Experiment (BATSE) aboard the NASA Compton Gamma Ray Observatory (CGRO) satellite provided initial clues of their cosmological origin.[228, 229] By localizing and monitoring GRB fading X-ray afterglow, the Italian Space Agency's *Beppo*SAX satellite, launched in 1996, has been able to measure the redshift of GRBs, confirming that they are of cosmological origin.[230] Even given an erroneous redshift-distance relationship, which has caused high-redshift GRB intrinsic luminosity to be grossly exaggerated, their energy output is still equivalent to converting a good portion of a star's mass into radiant energy in a few seconds.[231] A link between supernovae and gamma ray bursts has been suspected for some time but conventional physics has had no ready answers to explain the phenomenon.[232]

When an isolated large star undergoes catastrophic collapse, the wormhole that subsequently forms cannot be stable because there is no additional mass to feed the hole. Unlike the stable large holes at the cores of galaxies, which are fed with a continuous flow of energy from these rich cores, a wormhole formed by gravitational collapse of a star can have only a brief existence unless there is a companion star that can feed the hole. This phenomenon must initially manifest as a high-energy gamma ray burst (GRB) from the white hole side, which is like a momentary tiny AGN. Note that in contrast to conventional thinking, the location of the supernova and the location of the GRB are distinct, actually occurring at antipodes of the Universe with a cosmological redshift horizon half way between them. One implication of this idea is that the observed frequency of supernovae and the observed frequency of gamma ray bursts should be approximately the same. To test this hypothesis, it is important to accurately determine what percentage of the total population of both types of events are actually being observed and counted.

Because unwarranted faith in the accuracy of the Einstein field equations and the Schwarzschild metric was the foundation of all black hole research for the past forty years, the literature concerning black holes during that time does not correlate with empirical reality. A black hole is not an object with a mass having a single distinct spatial coordinate like a star or other astrophysical body. It is quite literally a hole in spacetime (i.e., an extended spacetime structure), not a localized body made up of matter. According to the foregoing discussion, there are no physical singularities where the laws of physics break down; rather, even in the event of catastrophic gravitational collapse, spacetime is smooth and continuous everywhere. Conservation of mass-energy is one of the most fundamental laws of physics, yet the existence of wormholes implies that this law does not hold locally in the region around either wormhole terminus. While mass-energy is never created or destroyed cosmologically, we may have a white hole region of space where mass-energy increases over time connected to a black hole region in which mass-energy decreases over time. This has important ramifications for cosmology, specifically concerning the origins and evolution of galaxies.

With the mechanism of wormholes, the Universe may constantly recreate itself in an eternal cycle of death and rebirth of galaxies that prevents general gravitational collapse by redistributing mass-energy across the Universe. Thus, the Universe would be eternal according to any particular clock. It will soon become generally apparent to educated people that we do not live in an expanding Universe that exists in a shared "cosmic time," but rather in an eternal dynamic equilibrium Universe that completely transcends our local experientially-based concept of time. While it is conceivable that the Universe may have been different in the past, reflecting some kind of cosmic evolutionary process, it seems likely that its currently observed general architecture has remained about the same over an infinite extent of time.

A number of people have been talking about the possibility of wormholes for decades, and now their intuitive ideas are vindicated. Other people, for example Steven Weinberg, have worked out important details of how matter behaves in conditions of intense heat and pressure, far surpassing that which can occur in the interior of stars. While it was assumed these conditions existed some moments after a single primordial creation event, it turns out that these conditions exist at the core "horizon" of black holes and white holes, which are opposite ends of wormholes through spacetime. Sophisticated and detailed mathematical models of the strong field limit will evolve from a new 21st-century model of gravitation that includes the concept of temporal geometry.

> Is something wrong with gravity? Is some unknown force acting on the [Pioneer-10 & -11] probes? This seems another indicator of my own pet theory that science has barely begun to grasp what's going on in the universe, and that in centuries to come, people will chortle regarding what we consider knowledge, in the same way we today chortle about those of past centuries who thought the Earth was flat or the air was full of phlogiston. (Conversation in the year 2105: "Can you believe that in 2005, people at Harvard actually thought the entire universe emerged as an explosion of a point with no dimensions?") [233,234]
>
> – Gregg Easterbrook

One may hope that the erudite Harvard community will absorb the contents of this dissertation and begin to expand on it in far less than a century. Easterbrook, a visiting fellow at the Brookings Institution, could have reversed the middle two digits and written instead, "Conversation in the year 2015…"

28. DARK MATTER

Following observational studies of the Coma cluster of galaxies in the 1930s, Fritz Zwicky noted that there was a significant discrepancy (two orders of magnitude) between the estimated mass of the cluster based on the luminosity of its constituent galaxies and its estimated virial mass based on its observed dynamical properties according to a Hubble expansion and Newtonian gravitational physics.[235] In 1964, Zwicky and Milton Humason of the Mt. Wilson Observatory published the last paper of a series in the *Astrophysical Journal*. In the abstract's last sentence, we find the first definitive claim for what is now commonly known as (otherwise undetected) "dark matter."

> An observational and theoretical analysis of the medium compact cluster of galaxies around NGC 541 has been initiated. … From the spatial distribution of the values of the velocity distribution, it may be concluded that the cluster is not expanding. The fact that the fainter galaxies have a greater velocity dispersion than the brighter galaxies indicates a tendency toward the establishment of equipartition of energy among at least the brighter cluster galaxies. … The indicative distance of the cluster, the indicative absolute photographic magnitude of its brightest member galaxy and the relative indicative mass-luminosity ratio, as determined from the Virial theorem, are respectively, D^* = 53.2 million pc, M^* = -20.2 and $\mathfrak{R} \sim 100$. This value of $\mathfrak{R}$ lies midway between those found for individual bright galaxies and those of very richly populated compact clusters of galaxies. Suggestions are discussed of how $\mathfrak{R}$ might be found to be drastically reduced because of the presence of various types of as yet undetected types of intergalactic matter.[236]

In spite of many decades searching for the mysterious stuff called "dark matter," independent evidence for it does not exist beyond its apparent gravitational effects. Thus, the alleged ubiquitous "dark matter" would have the improbable properties of being wholly unaffected by electromagnetic forces and emitting no radiation whatsoever. Moreover, while the vast majority of the Milky Way Galaxy is supposedly made up of "dark matter" there is no evidence for its existence in the Solar System; it is readily apparent that the only gravity acting in the Solar System is sourced from the constituent atoms in the Sun, the planets and other minor material bodies. The fanciful ideas for particles that have been put forward as possible candidates for "dark matter" have been categorized by an anonymous pundit as "Fabricated Ad hoc Inventions Repeatedly Invoked in Efforts to Defend Untenable Scientific Theories" (i.e., FAIRIE DUST). At face value, like the "phlogiston" of the 19th century, "dark matter" does not exist, yet, how does one otherwise explain the observed *apparent* gravitational effects of the "missing matter"? — If the Universe is not expanding, then galaxy clusters need not have extra invisible gravitating mass to account for the fact that they are not expanding. However, in addition to addressing this trivial first point, it is also necessary to account for the observed rotation curves of spiral galaxies.

Vera Rubin graduated from Vassar College in 1948 with an undergraduate degree in astronomy, later completing her doctorate at Georgetown in 1954. Her early ideas and research suggested inconsistencies with the Big Bang, which were not well received, yet she persevered in her career while also raising a family of four children and is now a staff astronomer at the Carnegie Institution for Science. Rubin made a major contribution to astronomy in the 1970s when her observational work first revealed that the velocity profiles of spiral galaxies are generally flat beyond the inner core.[237] This was a startling revelation, for at the time it was assumed that the velocity profiles must naturally exhibit decay consistent with the apparent mass distribution according to the observed luminosity profile. In his 1978 Ph.D. thesis, Albert Bosma later showed by radio astronomy observations that this property extends to orbiting clouds of hydrogen gas that exist far beyond the edge of the optical disk.[238]

Dynamic stability of an orbiting body requires a balance of forces; one expects the gravitational acceleration and the centripetal acceleration to be equivalent.

$$\frac{GM}{r^2} = \frac{v^2}{r} \quad \rightarrow \quad v = \sqrt{\frac{GM}{r}} \tag{93}$$

The conspicuous central bulge of spiral galaxies implies a significant associated mass concentration somewhat similar to the Sun of our solar system. Then a Newtonian point mass approximation governing the orbits of stars in the disk is a reasonable assumption, although one must also account for the radial increase in enclosed mass from the disk. The application of the virial theorem to the galactic system also implies that orbital velocities should decline with the radius.

$$v^2 \propto \frac{M}{r} \quad \rightarrow \quad v \sim \frac{1}{\sqrt{r}} \tag{94}$$

Numerous observed spiral galaxy rotation curves have been published. The actual measurements are difficult to make and the error bars are large. The generally accepted interpretation of these observations are reflected by the typical smooth curve shown in Fig. (80). A review of actual raw spiral galaxy rotation

curve data shows that while the typical conventional graph is revealing (i.e., there is definitely no Newtonian decline at large galactocentric distances), there is likely a divergence between actual data and the typical representation of observations that is driven by preconceived ideas.

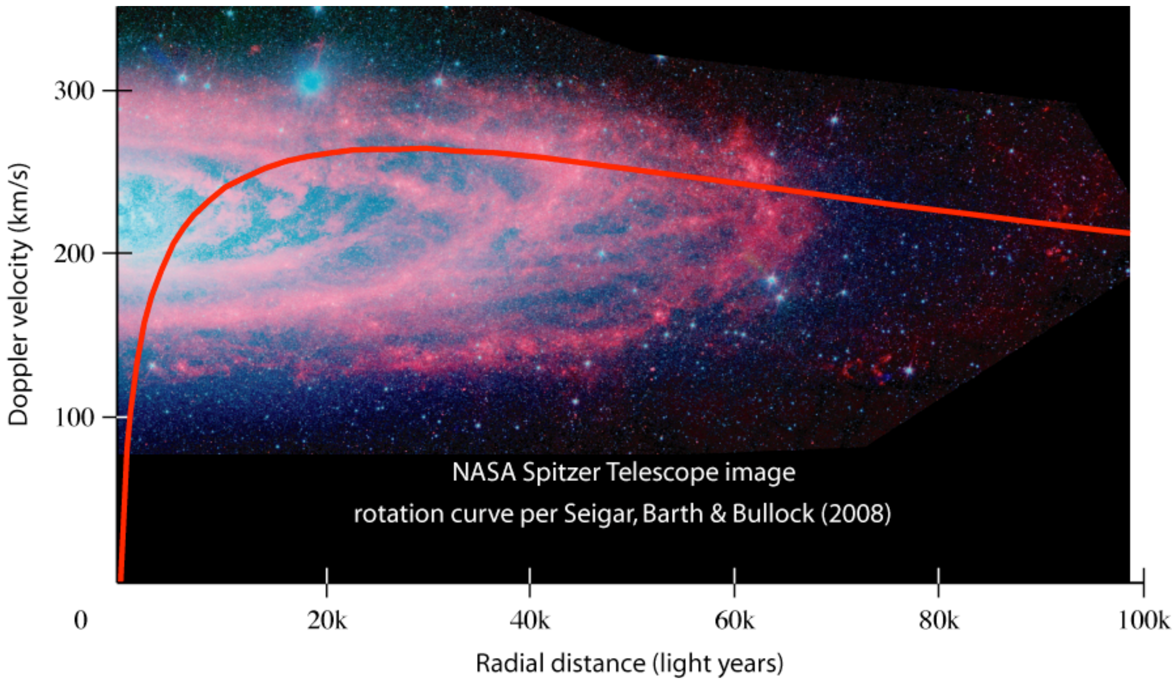


Figure 80 | Reported rotation curve for the Andromeda galaxy (M31). The curve extends beyond the visible disk to rotating hydrogen clouds observed in the radio spectrum. The nearly flat region (> 20k) showing no signs of expected Newtonian radial drop-off is typical for spiral galaxies. The background image showing half of the galaxy fit to the radial distance scale is in the infrared.

The existence of “dark matter” alleged to comprise about 95% of the Galaxy’s mass requires an exceedingly unlikely condition. In order to preserve the observed spatial distribution of visible and other normal matter in the thin galactic disk, virtually all of the gravitating dark matter must exist beyond the boundaries of any normal matter. Clearly the “dark matter” must orbit the galactic centroid in similar manner to globular clusters. Gravitational interaction between the imagined “dark matter” in necessarily random orbits and the normal matter in the disk would rapidly break up the intersecting region of the disk, dispersing its normal matter throughout the “dark matter halo.” Similar tidal stripping is observed for globular clusters, which must periodically pass through the galactic disk. Consequently, the innermost boundary of the “dark matter halo” must be farther out then the outermost boundary of a disk structure.

No discussion of spiral galaxy disks is complete without mention of the Tully-Fisher relation. In 1922, an Estonian astrophysicist named Ernest Oepik (a.k.a. Öpik) who spent the latter part of his career at Armagh Observatory in Ireland published an article in the *Astrophysical Journal*. Following is the first sentence of the abstract.

> *Andromeda Nebula*.—Assuming the centripetal acceleration at a distance r from the center is equal to the gravitational acceleration due to the mass inside the sphere of radius r, an expression is derived for the absolute distance in terms of the linear speed v_0 at an angular distance ρ from the center, the apparent luminosity i, and E, the energy radiated per unit mass.[239]

Oepik’s original idea, applied locally to Andromeda, was later expanded upon and made practical for great distances by R. Tully at the Observatoire de Marseille in France and J. Richard Fisher of the National Radio Astronomy Observatory (NRAO) in West Virginia. From their 1977 paper:

> We propose that for spiral galaxies there is a good correlation between the global neutral hydrogen line profile width, a distance-independent observable, and the absolute magnitude (or diameter). It is well known that the intrinsic luminosity of a galaxy is correlated with total mass, which is a derivative of the global profile width and is linearly dependent and that comparison of the total mass with such parameters as hydrogen mass, luminosity, and neutral hydrogen surface density can be used as a distance tool.[240]

The Tully-Fisher relation, which recognizes that to close approximation the intrinsic luminosity of spiral galaxies is proportional to the 4th power of the circular velocity ($L \propto V_c^4$) is presently considered to be one of the more accurate astrophysical secondary distance indicators. Although it is an empirical fact that this relationship holds true (more luminous galaxies spin faster) the theoretical derivation of the relationship is not sensible in that the assumptions do not correlate with the observation that the rotation curves are flat. In particular, the fundamental assumption in the theoretical derivation of the Tully-Fisher relation is that the centripetal acceleration of the observable luminous matter and the gravitational acceleration holding the galaxy together are in balance. In other words, the assumption is that the luminous matter dominates the mass of spiral galaxies. The popular modern idea that about 95% of galactic mass is "dark" is inconsistent with the Tully-Fisher relation.

Based on the totality of astronomical observations and scientific logic, it is reasonable to suspect that no "dark matter" actually exists. In science, one must not stray from first principles and one cannot simply invent arbitrarily new concepts that are in conflict with these principles in an attempt to explain empirical phenomena. The proper alternative to such an approach is to abandon preconceived notions and doggedly follow where the data leads. If Eq. (93) is indeed a governing equation, the implication of a nearly flat empirical rotation curve is that the ratio M/r is nearly constant. There are two possible explanations for this apparent relationship that one may consider. If one assumes that M is a constant over time, then it is necessary to invent "dark matter." If this phenomenon cannot be observed and is inconsistent with physical principles and other observables, then the remaining alternative is to consider the possibility of a time-varying value for the mass M.

Consider now a software simulation of galaxy formation and evolution based on the premise of a white hole with an approximately constant efflux of mass-energy over some extended period of time, which eventually terminates. The hole is assumed to be isolated in a region initially free of immediate external gravitational influence (e.g., an adjacent mature galaxy). Contrary to any previous simulation of spiral galaxy evolution, the total mass of the growing proto-galaxy is a linear function of time, rather than being a constant. Moreover, with the progress of time the galaxy grows outward from its core, rather than arising from the collapse of a fixed spatially isolated mass with time-varying density. If the white hole has a nearly constant flux, the total galactic mass (M) is linear with time. Similarly, the radius of the galactic disk (R) increases as an approximately linear function of time, at least initially, until enough of a central mass accumulates to produce an acceleration retarding outward radial motion.

$$M = kt \qquad R = v_0 t \tag{95}$$

Consequently, the velocity in Eq. (93) remains approximately constant for any localized outbound system of particles. Gas and dust are assumed to have acquired initial angular momentum near the core prior to migration in a spiraling outbound radial trajectory. — The Galactic core is known to have a stellar density about five orders of magnitude greater than the average for the Milky Way. Moreover, it is associated with strong radio emission similar to active galactic nuclei, which is likely to be a product of the *TGR* effect given the large amount of mass, strong gravitational fields and rapid velocities. Is or was the center of our galaxy a black hole or a white hole? The Big Bang theory provides a single context for the formation of spiral galaxies; over a comparatively short period of time (on the order of 1 billion years according to high-z observations interpreted as lookback time over a finite timeline), spiral galaxies are alleged to have formed due to the collapse of protogalactic clouds. This idea evolved because it is consistent with the standard cosmological model, but that model is no longer valid and cogent arguments against this theory of spiral galaxy formation gain credence. A simulation assuming a primordial white hole as having been the progenitor of the Milky Way and other spiral galaxies, which also incorporates the phenomenon of *TGR*, is likely to overturn the notion of "dark matter" in spiral galaxies.

29. FORMATION OF STARS AND PLANETS

The rotational kinetic energy dissipation mechanism behind the observed spin-down of stars and planets and the secular decay of their orbits (i.e., the *TGR* effect) must also play a key role in the initial formation of stars and planets from self-gravitating clouds of gas and dust within a galaxy. Given that the Solar System's planets orbit in a disk that is near to the solar equatorial plane, it is likely that they formed from a disk-shaped nebula. The standard model of planet formation involves core accretion whereby a large initial core is built by extreme inelastic collision of chunks of matter. How these chunks originated from gas and dust is not really explained, just assumed. An alternative theory of planet formation requires an imagined "gravitational instability" whereby a dense local region of gas somehow undergoes rapid collapse. No simulation has been able to demonstrate planetary formation according to this idea. However, applied to a rotating disk of matter, the *TGR* effect can be expected to promote accelerating collapse. The formation of planets within a protostar's accretion disk can be attributed to local eddies of various sizes, with the rocky planets forming from denser material nearer the core. Computer simulations incorporating the *TGR* effect are expected to successfully form virtual solar systems. A heretofore unexplained observational fact is that while the Sun contains about 99.85% of the Solar System's mass, it contains no more than 2% of its angular momentum. It is suspected that the Sun has lost the majority of its primordial angular momentum due an improbable imagined phenomenon called "magnetic braking" in which angular momentum was transferred to charged particles. As well as explaining ubiquitous examples of secular loss of angular momentum observed in real time, the *TGR* effect can be invoked to account for the angular momentum distribution of the Solar System.

30. RELATIVISTIC ENERGY

In an unusually brief paper entitled *Does the Inertia of a Body Depend Upon Its Energy-Content?* (translated) published in September 1905, Albert Einstein revealed the following momentous truth.

> *If a body gives off the energy L in the form of radiation, its mass diminishes by L/c².* [241]

The now widely familiar mathematical statement of this principle did not appear in the original paper.

$$E = mc^2 \tag{96}$$

Energy is a measurable physical quantity, so it is natural to think that energy is exclusively represented by a real number. However, beginning with Einstein, theoretical physicists of the 20th century failed to realize that Minkowski's formal mathematical framework for special relativity in terms of the complex numbers implies that Eq. (96) is a naïve form of a more general equation in the complex numbers. In fact, as concerns the precision of communication required in mathematical physics, Eq. (96) is fundamentally incorrect because it is incomplete. — It fails to make clear that mass energy (mc^2) is a magnitude ($|E|$) that represents the ability to do work, while relativistic energy (E) more generally incorporates two distinct energy components (rest energy and "momentum energy") whose linearly summed individual magnitudes typically greatly exceed the magnitude of the mass energy. Because Eq. (96) is one of the most elemental statements in the field of modern physics, it is certain that a correction, however subtle, should provide new insights and bring about important changes in physics. Indeed, this shall prove to be the case.

A familiar textbook equation that explicitly incorporates momentum (p) is easily derived from Eq. (96).

$$E = \frac{m_0 c^2}{\sqrt{1-\dfrac{v^2}{c^2}}} \quad \rightarrow \quad E^2 = \frac{m_0^2 c^4}{1-\dfrac{v^2}{c^2}} \tag{97}$$

$$E^2 - \left(mc^2\right)^2 \frac{v^2}{c^2} = m_0^2 c^4 \quad \rightarrow \quad E^2 - \left(mv\right)^2 \frac{c^4}{c^2} = m_0^2 c^4 \tag{98}$$

$$E^2 - p^2 c^2 = m_0^2 c^4 \tag{99}$$

Each of the three squared terms in Eq. (99) represent distinct forms of energy: mass energy (E), "momentum energy" (pc) and rest energy (m_0c^2). Momentum energy clearly represents the true energy equivalent of momentum in similar manner to how rest energy represents the true energy equivalent of intrinsic mass (m_0). In both cases, the large magnitudes produced by the coefficients are not intuitive.

Eq. (99) is expressed in proper form with both Lorentz covariant quantities on the left side equated to the Lorentz invariant quantity on the right. What is not immediately obvious upon cursory examination of the equation is that the left side of the equation is the *sum* of two squares, rather than a difference.

$$E^2 + (ipc)^2 = (m_0c^2)^2 \tag{100}$$

This elementary equation implies that the mass energy is less than the linear sum of the rest energy and momentum energy. The latter form merely emphasizes this fact by drawing attention to the geometric distinction between the imaginary-valued momentum energy and the real-valued rest energy. An improper variation of Eq. (99), in which respective Lorentz invariant and Lorentz covariant terms are mixed on the left hand side, is a Pythagorean formula ($a^2 + b^2 = c^2$) yielding a naïve "energy triangle" in the real plane.

$$(m_0c^2)^2 + (pc)^2 = E^2 \tag{101}$$

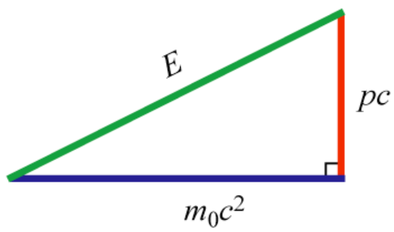


Figure 81 | The naïve Pythagorean relationship for Eq. (99). This triangle shows the implied geometric relationship between the magnitudes of the three energy manifestations, but it fails to recognize the distinction between imaginary momentum energy and real rest energy [Fig. (83) and Fig. (84)].

Eq. (99) implies a *complex* momentum-energy plane. The distinction between Fig. (81) and Fig. (82) is subtle but absolutely critical in the context of mathematical physics. Interpretation of an incorrect and incomplete mathematical expression obviously cannot provide a correct and complete physical model. This simple visual geometric model [Fig. (82)] makes it immediately clear that relativistic energy must be represented by a complex number as implied by the first principles only obscurely embodied in Eq. (99).

$$E = m_0c^2 + ipc \qquad |E| = mc^2 \qquad E^2 \equiv E\bar{E} \tag{102}$$

$$E = mc^2 e^{i \sin^{-1} \beta} \qquad \left[\beta \equiv \frac{v}{c}\right] \tag{103}$$

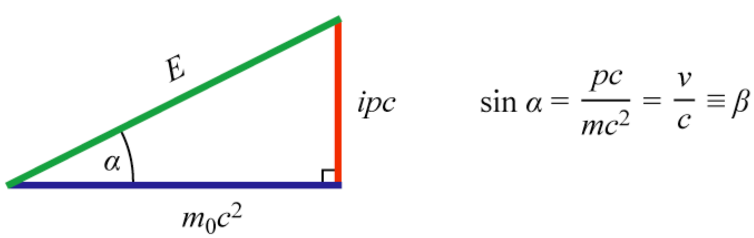


Figure 82 | The correct geometric relationship for Eq. (99) in the complex plane. The orthogonal geometric relationship between the rest energy component and the momentum energy component implied by the algebra is naturally reflected by the distinction between real and imaginary numbers.

It is unequivocal that Eq. (103) is the correct mathematical expression for relativistic energy. What is commonly known as "the Einstein energy equation" (96) is fundamentally incorrect in that it does not incorporate the required phasor term, nor does it indicate that mc^2 is the magnitude of a complex number. Indeed, most students of physics have falsely believed that E cannot be anything other than a real number expressing an observable. A review of the following simple algebra may be helpful in understanding the phasor form of the relativistic energy equation visually modeled by Fig. (82).

$$\beta \equiv \frac{v}{c} \qquad \alpha \equiv \sin^{-1}\beta \tag{104}$$

$$\cos\alpha = \sqrt{1-\frac{v^2}{c^2}} \qquad \sin\alpha = \frac{v}{c} \tag{105}$$

$$e^{i\alpha} = \cos\alpha + i\sin\alpha = \sqrt{1-\frac{v^2}{c^2}} + i\frac{v}{c} \tag{106}$$

$$mc^2 e^{i\sin^{-1}\beta} = mc^2\left(\sqrt{1-\frac{v^2}{c^2}}\right) + i\frac{mvc^2}{c} = m_0c^2 + ipc \tag{107}$$

In university textbooks of introductory modern physics, equations are routinely presented which make no distinction between the necessarily real-valued magnitude of an observable and the more fundamental underlying mathematical representation of phenomena according to mathematical physics. For example, in separate introductory discussions, the rest energy of a material particle and the momentum energy of a massless photon are both presented mathematically as measurable real numbers.

$$E = m_0c^2 \ \text{(correct)} \qquad E = pc \ \text{(incorrect)} \tag{108}$$

At some future time, the student is then introduced to the important concept of the energy-momentum 4-vector, which originated with Minkowski as an essential complement to the concept of spacetime. Although consideration of relativity should make it clear that the momentum energy of a particle cannot possibly be represented (fundamentally) by a real number, initial indoctrination of the second of the above two relationships creates a mental block. Consequently, Eq. (96) has been employed as a foundational element of modern physics instead of being recognized as naïve and misleading.

The energy-momentum 4-vector (p^μ) is tangent to the world line of a particle. Ignoring potential energy, the imaginary part of p^μ represents "total energy" (E) while the real part represents linear momentum (p). The world line of a photon is naturally at 45 degrees in the complex space-time plane. Consequently, it is trivial to observe that establishing a mathematical equality between the real and imaginary parts of a photon's energy-momentum 4-vector requires an imaginary coefficient ($E = ipc$).

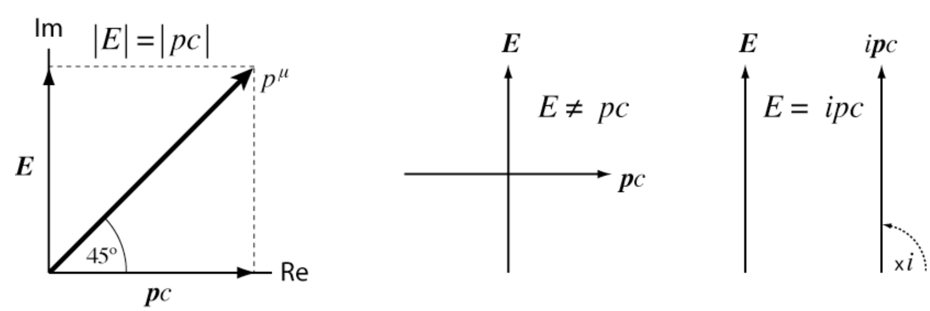


Figure 83 | The energy-momentum 4-vector of a photon. A mathematical statement specifying the energy equivalent represented by the linear momentum clearly requires an imaginary coefficient.

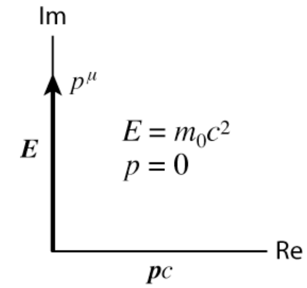


Figure 84 | The energy-momentum 4-vector of a particle in its rest frame. A mathematical statement specifying the energy equivalent of rest mass requires no imaginary coefficient.

Like spacetime, which has two integrated distinct measurable manifestations (space and time), energy also has two such observationally distinct yet integrated manifestations (mass and radiation). In both cases, the nature of the integration allows that either of the two forms may transform into the other form. The mathematical distinction between real-valued rest energy and imaginary-valued momentum energy *encodes their relativistic duality* and the associated distinction between particle and wave manifestation.

Eq. (103) is in no way a radical departure from conventional relativistic physics. On the contrary, this new equation is nothing more than a polished formal restatement of Eq. (99), recognizing the previously obscured fact that E^2 in that equation is the square of a *complex modulus*. Preconceived notions and incorrect assumptions obscured what is really quite obvious in hindsight. However, this seemingly small improvement in mathematical form yields profound new physical insights of immense significance.

31. MOMENTUM-DRIVEN FIELD ENERGY

When the rest energy and momentum energy components of mass energy are properly expressed as their respective real and imaginary values, it becomes transparently obvious that the linear sum of their wholly independent magnitudes (assuming that both are not zero) is necessarily greater than the magnitude of the mass energy. A formal mathematical statement of this fact employs Schwarz's inequality applied to Eq. (103) with the equality holding only if one of the two summed components is zero.

$$mc^2 \leq \left(m_0c^2 + |ipc|\right) \tag{109}$$

The relationships shown in Fig. (85), which are implied by first principles, are clear. However, as was similarly true for 17th-century astrophysics, immersion of the academic establishment in a false paradigm of artificially created complexity has obscured an exceedingly simple and obvious physical reality.

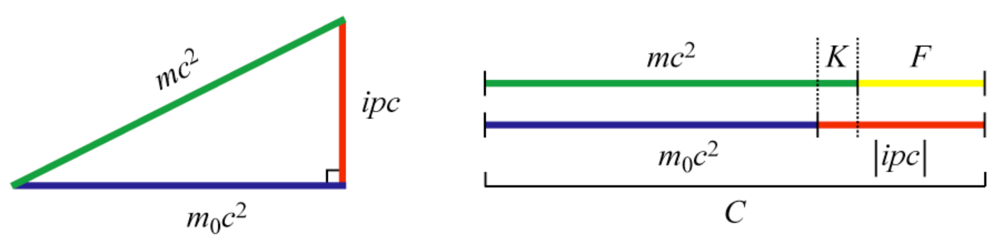


Figure 85 | The complete energy budget (C) exceeds the mass energy by the magnitude F. The linear sum of the rest energy and the momentum energy magnitudes constitutes the *complete* relativistic energy budget (C). The extractable mass energy (mc^2), which can to do work, is a subset of this systemic energy budget. Energy conservation requires that the physical manifestation of the difference between these two energies ($F = C - mc^2$) be identified. The magnitude of this energy can also be expressed as the difference between the magnitude of the momentum energy and the magnitude of the relativistic kinetic energy ($F = pc - K$).

The sum of a particle's relativistic mass energy and its potential energy represents the theoretical maximum amount of energy that can be extracted from it. This energy, associated with the ability to do work, is generally referred to as the "total energy" of the particle. This nomenclature strongly suggests that every component of the energy budget has been accounted for, so it is natural to complacently assume that no more systemic energy exists. In spite of being mathematically naïve (because the E^2 term leads to the false assumption that E is a real number) upon thoughtful consideration even Eq. (99) implies that this terminology is misleading. Disregarding potential energy, the linear sum of the two distinct energy magnitudes yielding mass energy clearly provides a *complete* energy budget for a particle ($m_0c^2 + pc$) that is typically well in excess of its mass energy. The conventional concept of "total energy" leaves out a significant amount of the complete *systemic energy*, all of which must be accounted for in accord with energy conservation. This excess energy is expressed by Eq. (110) and represented by the yellow bar labeled F in Fig. (85). The energy F, which is the remaining momentum energy of a particle after removing the part incorporated in the relativistic kinetic energy component K of the mass energy, must be accounted for. By a process of elimination, the creation of some kind of field is the only possibility, so F may justifiably be referred to as the "field energy," distinguishing it from the relativistic mass energy, incorporating the kinetic energy, which itself is only a subset of the momentum energy.

$$F = \left(m_0c^2 + pc\right) - mc^2 = pc - K \tag{110}$$

32. THE MOMENTUM WAVE

In the context of energy, conventional physics makes a broad distinction between a material particle (e.g., an electron) and a massless particle (e.g., a photon). This distinction was largely defined by the following two equations relating the energy of the particle to a frequency according to Planck's equation.

$$hf_m = mc^2 \qquad hf_p = pc \tag{111}$$

Most fundamentally, quantum mechanics is based on the empirically verified notion that all particles exhibit wavelike behavior according to the generalized de Broglie relation.

$$\lambda = \frac{h}{p} \tag{112}$$

Accordingly, the phase velocity of the matter wave (w_m) exceeds the speed of light. This is not considered to be an unphysical result as it is accepted that the group velocity of the matter wave packet corresponds to the velocity of the source particle (v) and it is understood that the superluminal matter wave transmits no information beyond the confines of the localized wave packet.

$$w_m = \lambda f_m = \frac{h}{mv} \cdot \frac{mc^2}{h} = \frac{c^2}{v} \tag{113}$$

Consider now the fresh perspective provided by Eq. (103) as concerns an oscillating subatomic particle. The systemic energy of such a particle is composed of two distinct energy manifestations: the rest energy and the momentum energy, each of which must be treated separately. To reiterate, the relativistic kinetic energy is only a subset of the momentum energy. Then the mass energy, which is the linear sum of the rest energy and this kinetic energy, is only a subset of the complete systemic energy of the particle.

$$\mathrm{Re}\left[mc^2 e^{i\sin^{-1}\beta}\right] = m_0c^2 \qquad \mathrm{Im}\left[mc^2 e^{i\sin^{-1}\beta}\right] = pc \qquad \left|mc^2 e^{i\sin^{-1}\beta}\right| = mc^2 \tag{114}$$

According to Eq. (112) there is no wavelength (and therefore no frequency) associated with rest energy because there is no associated momentum. On the other hand, Eq. (112) implies that the momentum energy generated by a material particle is associated with a wave having a wavelength (h/p) and phase velocity c. Though different from a photon, the momentum wave produced by an oscillating fundamental subatomic particle or composite particle shares these two fundamental properties with photons.

$$w_p = \lambda f_p = \frac{h}{p} \cdot \frac{pc}{h} = c \tag{115}$$

This implies that oscillating subatomic particles (e.g., bound quarks) generate a momentum wave (hereafter "*p*-wave") with a phase velocity of *c*, characteristic energy *pc*, and wavelength *h*/*p*. The phase velocity of the *p*-wave implies that it manifests as a distributed periodic field. The energy distribution may be generally modeled as an isotropic spherical standing wave surrounding the particle. As *p*-wave modulation propagates at the speed of light and is not associated with electromagnetic radiation, the question arises as to what might be waving. The answer is clear; *spacetime itself* is waving. This is simply the application, in the context of *p*-wave energy, of Einstein's key idea that mass-energy influences spacetime geometry. Thus, the positive energy of the *p*-wave creates a geometrically correlated spacetime potential in the form of a wave. The net energy of the two complementary waves is zero, which balances the energy budget. Another perspective is that oscillating bound subatomic particles continually produce *p*-wave energy with no net loss in energy similar to the way in which it is understood that atomic electrons restricted to a standing wave orbit suffer no net loss in energy due to their acceleration; the field continually returns the energy to the source particle in a reciprocating relationship.

Energy conservation in the context of the isotropic radial propagation of the momentum wave requires the amplitude of the *p*-wave to decrease linearly with radius from the source particle according to

$$A \propto \frac{\sin r}{r} \tag{116}$$

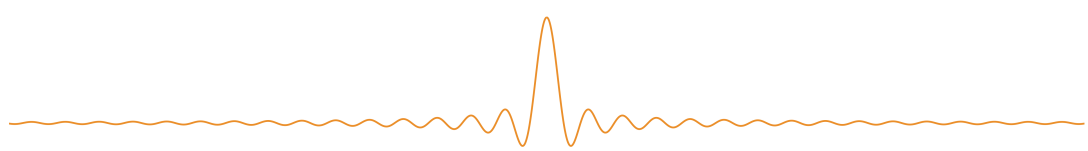


Figure 86 | *p*-wave amplitude.

Consequently, the local energy of the wave, which is proportional to the square of the amplitude, subscribes to Eq. (117). After the initial sharp decline from the central peak, the inverse square law applies to the decline in the energy of the wave.

$$E_p \propto \left(\frac{\sin r}{r}\right)^2 \tag{117}$$

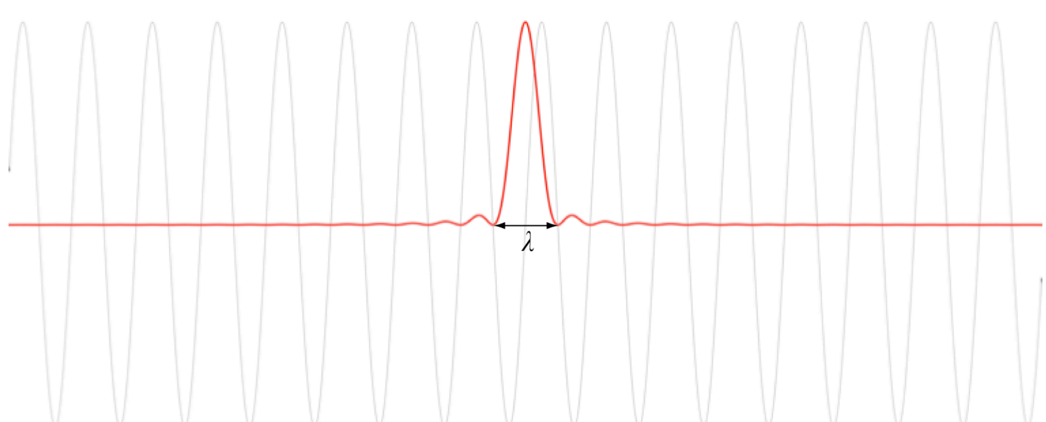


Figure 87 | *p*-wave energy in red superimposed on a sine wave.

The kinetic energy K associated with the localized source particle is a subset of the p-wave energy, represented by the peak amplitude of the wave that encapsulates the particle. The manifestation of the kinetic energy of a particle, when it is brought to rest and the p-wave energy vanishes, can be envisioned as the collapse of this core wave at the immediate location of the particle.

33. THE ROLE OF THE MOMENTUM WAVE IN DIFFRACTION

In diffraction experiments, a localized particle is emitted at a source and a localized particle impact is detected on the target screen. Therefore, the phenomenon of diffraction must be fundamentally attributed to the Heisenberg uncertainty principle (HUP), not to Fraunhofer diffraction geometry applied to an imagined incident plane wave. While the latter interpretation may be mathematically functional, it is not physically fundamental.

$$\Delta x \cdot \Delta p_x \geq \frac{\hbar}{2} \tag{118}$$

As the width (Δx) of the diffraction slit is decreased, the lateral position of the incident particle at the slit is known to increasing accuracy. It follows from Eq. (118) that the magnitude of the uncertainty in lateral momentum (Δp_x) of the particle must increase. While one may attribute the observed spreading of the diffracted particles to HUP, there is no component of this principle that implies forbidden values of Δp_x that might explain the observed minima (i.e.,dark bands) in the familiar single-slit diffraction pattern.

Figure 88 | A typical single-slit diffraction pattern on a target screen produced by a laser.

When quantum mechanics was being developed in the early 20th century, a familiar phenomenon that could be used to readily explain the observation of particle diffraction, dating back to Thomas Young's demonstration of two-slit diffraction to the Royal Society in 1803, was wave interference. In this context, a sufficiently narrow single slit (i.e., less than one wavelength) is understood to behave like two half-slits. The observed dark bands in single-slit diffraction are conventionally attributed to destructive interference of distinct wavefronts emanating from opposite sides of a narrow slit. The subjective concept of wave-particle duality (complementarity) emerged as a key element of the Copenhagen interpretation of quantum mechanics and has provided the *de facto* explanation for diffraction. This interpretation argues that the particle manifests as a kind of nebulous spatially extended wave after passing through the slit, prior to its detection as a distinct localized particle upon impact with the screen, which is commonly referred to as "collapse of the wave function." This interpretation, which was with rare exception universally adopted by the physics community in the latter part of the 20th century, contrasted sharply with a simpler and more rational explanation for the phenomenon originally proposed by Louis de Broglie and Albert Einstein, who was famously antipathetic to the popular conventional interpretation.

> [Einstein] believed in the concentration of the energy in quanta and that these quanta have structures similar to particles. However, their motion is governed by what he called *Führungsfeld*—that is, "guiding field"—and this obeys the equations of electrodynamics. [As he was unable to reconcile it with the conservation laws of energy and momentum,] Einstein never published the Führungsfeld idea. – Eugene P. Wigner [242]

> In order to explain this [wave-particle] duality of their behavior [photons, electrons, etc.], Einstein proposed the idea of a "guiding field" (*Führungsfeld*). This field obeys the field equation for light, that is Maxwell's equation. However, the field only serves to *guide* the light quanta or particles, they move into the regions where the intensity of the field is high. This picture [...] has, obviously, many attractive features. Yet Einstein, though in a way he was fond of it, never published it. – Eugene P. Wigner [243]

Einstein's private ideas that he shared with Eugene Wigner were apparently very similar to the early ideas of Louis de Broglie.[244]

> While the founding fathers agonized over the question 'particle' *or* 'wave', de Broglie in 1925 proposed the obvious answer 'particle *and* wave'.
>
> Is it not clear from the smallness of the scintillation on the screen that we have to do with a particle? And is it not clear, from the diffraction and interference patterns, that the motion of the particle is directed by a wave? De Broglie showed in detail how the motion of a particle, passing through just one of two holes in screen, could be influenced by waves propagating through both holes. And so influenced that the particle does not go where the waves cancel out, but is attracted to where they cooperate. This idea seems to me so natural and simple, to resolve the wave-particle dilemma in such a clear and ordinary way, that it is a great mystery to me that it was so generally ignored. Of the founding fathers, only Einstein thought that de Broglie was on the right lines. – J. S. Bell [245]

When Hermann Minkowski formalized special relativity in terms of the complex numbers in 1908, an impetuous young Albert Einstein referred to his work as "superfluous erudition." It is no wonder that Minkowski once referred to his former student, Einstein, as a "lazy dog." If only young Einstein had paid respectful attention to his mathematics professor, his creative genius would have been better rewarded. The "guiding field" he so accurately imagined was none other than the *p*-wave, whose existence is implied by the complete energy budget of a particle in the context of special relativity. If Einstein had just realized that the domain of his energy equation was the complex plane according to the mathematical foundation of special relativity and not the real numbers, his physically intuitive ideas concerning quantum mechanics would not have remained obscure and overshadowed by Niels Bohr's illogical yet dominant "Copenhagen interpretation" of the mathematics, which attempted to describe observations.

The wave function in quantum mechanics described by the Schrödinger equation describes a linear superposition of different states, but actual measurements are always made of a physical system in a definite state. For example, in the two-slit particle diffraction experiment, which has been conducted firing only one particle at a time, it is the actual impact locations of whole and observationally indivisible particles that measurably hit the target screen. However, the related formal mathematics describes only the statistical probability for the lateral distribution of all the particles that make their way to the screen. No previous interpretation of quantum mechanics describes how the mathematical probabilities are converted into distinct measured physical outcomes.

This "measurement problem" is immediately solved when we understand the mathematical distinction and corresponding physical distinction between the energies of the matter wave (mc^2) and *p*-wave ($|ipc|$). The *p*-wave is a spherical standing wave that surrounds the host particle, creating a distinct periodic energy field, which affects spacetime in accord with the fundamental interpretation of general relativity. Consequently, at quantum scale, the geometry of spacetime is periodic, rather than smooth, and the distinction between a particle and its *p*-wave is similar to the distinction between a source body and its gravitational field at macroscopic scale; the latter does not exist without the former, but they are certainly not the same thing. Rational intuition tells us that in the two-slit particle diffraction experiment, a given particle can pass through one slit or the other, not both. The idea that the particle may not have passed through either slit between the source and the target screen, which has been discussed as a conceivable interpretation of the observed phenomenon, simply makes no sense.

Fig. (89) is a schematic of double-slit diffraction, showing a particle having a 50% probability of passing through one or the other of the two open slits, yet in either case its *p*-wave energy clearly has a 100% probability of simultaneously passing through both slits. We may imagine the slits as two large holes punched through a fine-meshed filter and the *p*-wave energy as liquid passing through the filter. Like water pouring through such apertures in a filter, the *p*-wave energy takes the path of least resistance, passing primarily through the open slits, although it may be capable of permeating the physical barrier. The interference pattern shown on the far side of the two-slit barrier is of the *p*-wave energy and so must be interpreted as a *potential energy field*, rather than a statistical abstraction representing an unlikely amorphous form of the electron itself. This interference pattern has nothing to do with the conventional concept of matter wave (*m*-wave), which is restricted to the *p*-wave center.

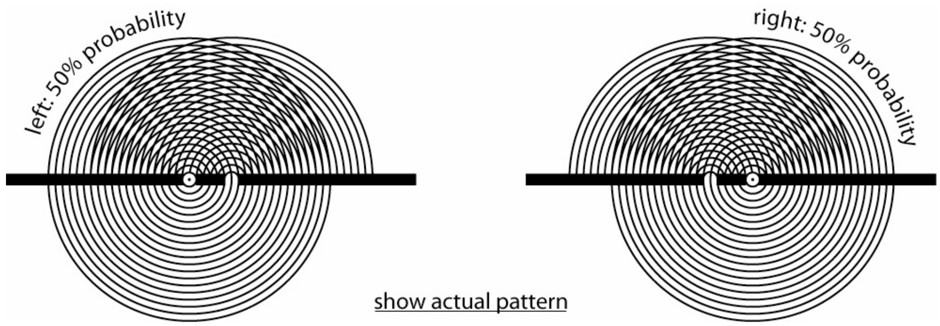


Figure 89 | Double-slit diffraction. A localized particle, represented by a matter wave (*m*-wave) with energy mc^2, which is encapsulated within the core (innermost circle) of the *p*-wave, may pass through one or the other of both open slits. In practice, there is a 50% probability of each scenario shown here. The interference pattern shows the *p*-wave energy of the single particle ($|ipc|$), which has a 100% probability of passing through both open slits. Like all particles, photons have an *m*-wave as well as a *p*-wave; however, for massless particles the two energies are uniquely identical.

The geometric deformation of spacetime in the presence of energy is conventionally associated exclusively with the gravitational field of a ponderous object, yet this principle of physics should be valid at all length scales. At quantum scale, energy manifests in the form of a wave, so at this scale the response of spacetime to the presence of energy in the form of a wave is certain to be a complementary wave, certainly not the same kind of smooth deformation one may associate with the gravitational field of a macroscopic object. Consequently, the moiré pattern of the *p*-wave energy shown in Fig. (89), must be interpreted as a potential energy barrier resembling the conceptual schematic shown in Fig. (90) in black. The crests of the interfering *p*-wave correspond to the troughs of spacetime observed at the length scale of its wavelength, while the troughs of the *p*-wave correspond to the crests of spacetime.

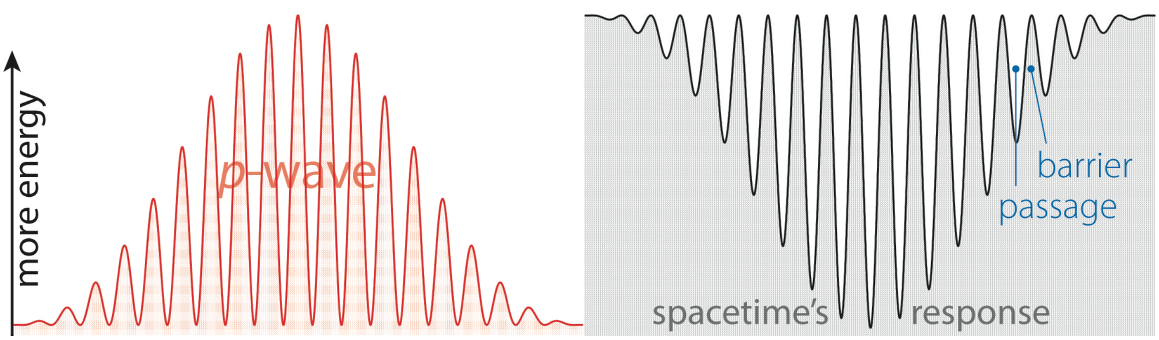


Figure 90 | Energy distribution of double-slit *p*-wave interference and spacetime's response. Upon confrontation with the double-slit barrier, the incident *p*-wave passes through the slits and interferes with itself. The energy of the *p*-wave, which corresponds to the moiré pattern in Fig. (89) resembles the red waveform on the left. Spacetime responds to the presence of this energy with a geometrically correlated waveform; *p*-wave energy maxima produce spacetime minima while *p*-wave minima yield spacetime maxima. In a loose sense, the spacetime structure on the right represents a kind of quantum-scale "gravitational field." Its maxima function as potential barriers to an incident particle (e.g., an electron). The appearance of light and dark bands in the double-slit experiment is a rational indication of quantum-scale *periodic spacetime geometry* produced by *p*-wave interference.

Richard Feynman claimed that understanding the double-slit diffraction phenomenon was the key to understanding all of quantum mechanics. — To a single particle passing through one of the open slits with inherently uncertain lateral momentum (Heisenberg uncertainty principle) spacetime immediately after the slits presents a geometric energy barrier resembling a mountain range of peaks and valleys as a response

to the periodic energy pattern of the interfering *p*-waves. The particle is forced to go around the barriers, and which interstitial passage it goes through is related to the lateral position of the passage, with a more central route a statistically more likely path among the possibilities. The striped interference pattern that is observed on the target screen is of a large population of whole particles, each striking a particular position on the screen, one at a time. This is a rational reflection of the spacetime barrier that each particle has negotiated prior to impact and measurement. The momentum-wave energy must pass through both open slits undisturbed in order for the interference pattern to manifest and any attempt to measure which slit a particle goes through destroys the *p*-wave interference pattern shown in Fig. (89). When it is understood that the *p*-wave energy field is effectively exerting forces on each particle that restrict its path to the screen, the observed results of the experiment are no more mysterious than the modeled effects of a magnetic field on the path of a charged particle. In hindsight, the conventional interpretation of the observed diffraction pattern in the double-slit experiment as the constituent particles having had no definite trajectory through space between the diffraction barrier and the screen is an illogical *ad hoc* model of the mathematics in the absence of a more rational explanation.

Along these lines, Erwin Schrödinger wrote in 1959,

> With very few exceptions (such as Einstein and Laue) all the rest of the theoretical physicists were unadulterated asses and I was the only sane person left. . . . The one great dilemma that ails us . . . day and night is the wave-particle dilemma. In the last decade I have written quite a lot about it and have almost tired of doing so: just in my case the effect is null . . . because most of my friendly (truly friendly) nearer colleagues (. . . theoretical physicists) . . . have formed the opinion that I am—naturally enough—in love with 'my' great success in life (viz., wave mechanics) reaped at the time I still had all my wits at my command and therefore, so they say, I insist upon the view that 'all is waves'. Old-age dotage closes my eyes towards the marvellous discovery of 'complementarity'. So unable is the good average theoretical physicist to believe that any sound person could refuse to accept the Kopenhagen oracle. . . [246]

Theoretical physics must eventually lead to objective empirical evidence that differentiates between academic arguments and accurate physical insight. The question then arises as to whether there may be an empirical test to distinguish between the conventional interpretation of quantum mechanics and the concept of the momentum wave as the "guiding field." Unlike the nebulous de Broglie wave, the *p*-wave produced by a material particle is subject to a Doppler shift. A transmission electron microscope, which may have an accelerating potential of 200 kV, can accelerate an electron to a speed exceeding half the speed of light. At this speed, the de Broglie wavelength of an electron is 4.85 picometers, but the *p*-wave will incur a relativistic Doppler blueshift to 2.80 picometers. Diffraction data using relativistic electrons, which conventionally assumes a de Broglie wavelength, requires a Doppler correction if the *p*-wave is responsible for particle diffraction. To give perspective on the absolute magnitude of this correction, consider that the diameter of a typical atom is on the order of 300 picometers, so the correction is less than 1% of a typical atomic diameter. SLAC might be a superior platform for this experiment.

34. THE ROLE OF THE MOMENTUM WAVE IN THE ATOMIC NUCLEUS

The measured magnetic moment of a neutron implies that it contains oscillating charged particles, so it appears certain that nucleons are composed of distinct charged quarks. Assuming a confinement region on the order of half the nucleon radius, the Heisenberg uncertainty principle implies a minimum momentum (p_q) of each quark confined within a nucleon.

$$p_q \geq \frac{\hbar}{2\Delta x} \qquad \left[\Delta x \sim 5\times 10^{-16}\ \mathrm{m}\right] \ \rightarrow p_q \sim 10^{-19}\ \mathrm{kg\cdot m\cdot s^{-1}} \tag{119}$$

Consequently, quark confinement (given 3 quarks per nucleon) is certain to yield an internally generated per nucleon momentum energy that compares to the measured nucleon rest energy of ~939 MeV.

$$\sum_3 p_q c \geq 592\ \mathrm{MeV} \tag{120}$$

Confinement of the composite nucleons within the nucleus produces an additional though typically smaller contribution to the *p*-wave field energy produced by atomic nuclei per unit mass. It is important to consider that variations in nuclear architecture can be expected to cause small variations per unit mass in the *p*-wave energy produced within the nuclei of distinct elements. Electrons and thermal molecular vibrations make additional small contributions to the total momentum energy generated by an atom. It is also important to consider that *p*-waves must interfere, both at subatomic scale and at astrophysical scale.

The existence of the *p*-wave is not an open question; it is implied by first principles. Because energy conservation precludes the *p*-wave from radiating energy away from the source particle, a complementary potential field must exist so that the sum of the two energies, having identical magnitude but opposite polarity, exactly cancel each other out. This response of spacetime to *p*-wave energy yields a strong binding potential with a sharp boundary having a diameter on the order of the measured nucleon diameter. Consequently, this binding potential is indistinguishable from the nuclear strong force. Moreover, wave interference produces an internal fine structure of isolated potentials, creating an elegant model of a nuclear shell structure and a means of precluding collapse. Occam's razor suggests that there is no reason to invent an entirely separate phenomenon (an exchange force mediated by "gluons") to account for the nuclear strong force when a phenomenon exists that rests on first principles and is already in place to perform this function. The nuclear strong force is described exclusively by spacetime wave mechanics.

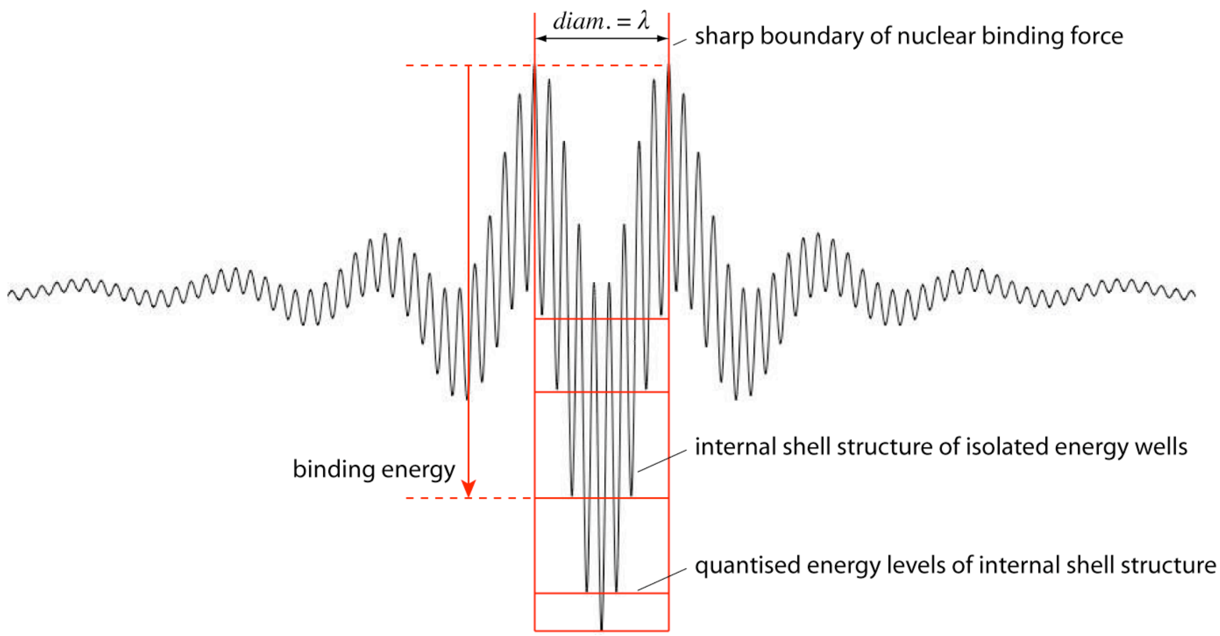


Figure 91 | Conceptual schematic diagram of nuclear *p*-wave interference fine structure.
In a typical atomic nucleus ($A > 1$), *p*-waves are produced by each bound quark and also by each composite nucleon. Each *p*-wave is sourced from the unique and dynamical physical location of its individual host particle. Individual *p*-waves must interfere with one another, producing a composite wave with a greater wavelength than the constituent *p*-waves. Adding additional nucleons having mutual proximity allows for effective constructive interference of their *p*-waves and thus tends to increase nuclear binding energy. Nuclei with an integer number of alpha particle sub-components naturally exhibit higher binding energy. At the peak of the nuclear binding energy curve, the *p*-waves of nucleons added to the periphery of the now larger nucleus cannot interfere as effectively with the internal nucleon *p*-waves; the binding energy curve declines after ^{62}Ni. Proton Coulomb repulsion fuels internal nuclear momentum, while neutrons function to reduce internal momentum. As atomic number increases, proportionately more neutrons are required to reduce internal nuclear momentum as required for nuclear stability. As the nuclear radius continues to grow, the effectiveness of *p*-wave interference must decline, so there exists a maximum size of a stable nucleus.

A synthesis of the definition of relativistic energy and the principle of energy conservation implies the ubiquitous existence of the *p*-wave while the Heisenberg uncertainty principle quantifies the magnitude of the *p*-wave energy produced by a nucleon. Thus, three of the most fundamental first principles in physics imply an emission of radiant energy associated with internal nucleon momentum, similar to the fact that first principles imply that a magnetic field is produced by the relative motion of charged particles. Ignoring the Doppler effect, which is insignificant for non-relativistic particle velocities, the *p*-wave manifests as an isotropic periodic scalar field whereby every point in space is associated with an energy value according to the local amplitude of the *p*-wave at that coordinate. The geometric interpretation of this scalar field in spacetime yields a deep central potential well (i.e., a quantum "gravitational field").

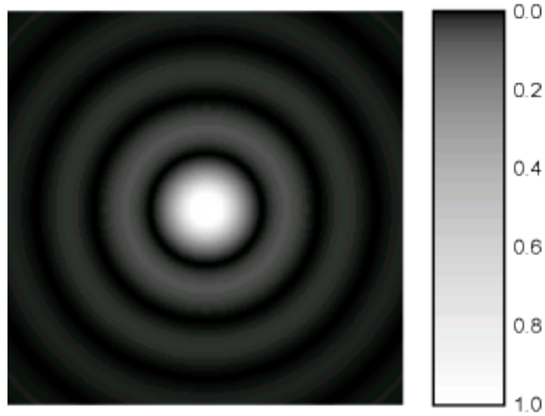


Figure 92 | Isotropic *p*-wave energy distribution: an Airy disk in three dimensions.

Ignoring internal fine structure caused by wave interference, Fig. (92) is a 2-dimensional representation of the 3-dimensional *p*-wave energy distribution produced by the internal quark momentum of a nucleon. The diameter of the bright central region corresponds to the quark *p*-wave wavelength of ~10^{-15} meter as shown in Fig. (87). This same region coincides with the sharp boundary of the strong force. As previously mentioned, energy conservation implies that the *p*-wave energy is inversely proportional to the square of the radius. As an atomic radius of one angstrom represents 10^5 wavelengths, the nucleon's *p*-wave energy has decreased by a factor of 10^{10} at this radius. At a distance of one millimeter from the nucleon ($10^{12}\ \lambda$) the *p*-wave energy has decreased by a factor of 10^{24} and at 6000 kilometers (approximate Earth radius) by a factor of about 10^{43}. It is then immediately clear that the relative magnitude of the *p*-wave energy within the boundary of the atomic nucleus is enormously greater than at atomic, let alone astrophysical, scale.

35. THE ROLE OF THE MOMENTUM WAVE IN GRAVITY

Heretofore, the conventional approach to a quantum description of gravity was to imagine the exchange of quantum particles (i.e., "gravitons") between bodies, which produced their gravitational attraction, yet this idea naïvely fails to abandon Newtonian anachronisms. A metric theory of gravity unequivocally maintains that there is no immediate interaction of a force *per se* between gravitating bodies that might be mediated by such particles. Moreover, a metric theory of gravity implies that photons pursue a geodesic in spacetime rather than the incompatible alternative idea that their trajectory is affected by exchanging a kind of 'attraction particle' with a gravitating body. If graviton quanta indeed communicate the existence of gravitating mass to the surrounding environment, how could they interact with a radial photon departing at the speed of light, which redshifts on account of the gravitational field? Obviously, they could not, so one may immediately conclude that gravity is not produced by an exchange of particles that mediate a force. The identical warped spacetime geometry generated by the quantum energy source of the gravitational field, which defines the trajectory and orbital energy of material bodies in the field, similarly defines the trajectory and frequency of photons in the field.

Three centuries ago, Isaac Newton simply assumed that the coefficient (G) in his equation of gravity was a universal constant, similar to our present-day understanding of the precisely measured speed of

light in vacuum. For all astrophysical gravitational fields, the value of "Big *G*" is obscured in the compound measured standard gravitational parameter *GM*, which for the Earth is now claimed to be known to a precision of about two parts per billion.[247] As it is only this composite parameter for a particular astrophysical body that correlates to accurately determined observables, indirect estimation of any astrophysical mass *M* has been based on estimation of the composite value *GM*, various independent experimentally determined values of *G*, consensus on the uncertainty of its value, and the assumption now put into question that it is a universal constant.

Newton's assumption that *G* is a universal constant was made at a time when there was no knowledge of atomic structure, let alone subatomic structure. It leads to the conclusion that all material bodies generate a gravitational field proportional to their mass that is qualitatively identical, regardless of size. Consequently, an electron is imagined to produce a tiny gravitational field whose only difference from that of the Sun is determined by the ratio of their respective masses. It should have been clear some time ago that Newton's assumption, although practical in most cases, is not sensible upon considering the source of gravitation at the quantum scale. Moreover, any successful theory of gravity, especially a quantum theory of gravity, must address the energy source of the gravitational field.

The existence of the *p*-wave is incontrovertible. It is a consequence of relativistic and quantum physics that was "hiding in plain sight" within Eq. (99) for about a century. Because the vast majority of *p*-wave energy is sourced from the internal momentum of quarks, the *p*-wave energy produced by a material body is essentially proportional to its mass. Also, in accord with energy conservation, the *p*-wave energy density is inversely proportional to the square of the radius from the source. At quantum scale, the *p*-wave produces a periodic energy distribution, yet superposition of these decoherent waves from all of the atoms (nucleons) present in a mass (e.g., about 10^{57} nucleons for a solar mass) produces a smooth energy distribution of unlimited range that naturally follows the inverse square law. Consequently, it is almost obvious that the *p*-wave is responsible for the creation of the gravitational field.

While the electric field is observed to emanate from individual subatomic particles, the gravitational field can only be observed to emanate from a large conglomerate of atoms. A successful search for the quantum source of the gravitational field, which ideally can be empirically verified by some experimental observation, must consider the phenomenon in the context of a hierarchical system of particles with a measurable gravitational field, not a single atom or component thereof. — As compared to the momentum energy produced by bound quarks, a comparatively smaller contribution to the *p*-wave energy produced by a composite mass arises from the bulk momentum of the composite nucleons due to nuclear confinement, electron momentum induced by Coulomb forces that vary with atomic number, and the thermally induced momentum of composite atoms and molecules. Consequently, while the magnitude of *p*-wave energy produced by a material body is very strongly dominated by its mass, factors such as its chemical makeup and even its temperature will have some small but not insignificant effect.

Empirical evidence suggests that the alpha particle is a compact sub-unit of nuclear architectures. Nucleons that are not integrated within an alpha particle can be expected to oscillate in an orbital mode, implying a greater Δx and so a smaller composite *pc* than those bound to an alpha particle. Consequently, the gravitational potential per unit mass (i.e., the measured value of *G*) can be expected to vary slightly according to the chemical composition of the source mass. Isotopes whose atomic mass number is evenly divisible by 4 (e.g., ^{56}Fe) can be expected to yield a slightly higher value of *G* than isotopes that contain "free" nucleons that cannot be bound to an alpha particle (e.g, ^{58}Ni). In general, isotopes or molecular compounds with greater internal momentum should yield a higher value of *G*.

Excluding the speed of light, *G* has the longest history of experimental measurement of all empirically determined fundamental physical values. With a few creative exceptions, almost all measurements of *G* have used variations of the torsion balance technique pioneered by Henry Cavendish in 1797. The typical modern torsion balance employs a precisely known source mass that creates a minute gravitational acceleration on a small horizontal pendulum suspended by a very fine fiber. The gravitational field of the source mass creates a torque on the pendulum that is reflected by a measured frequency change in a small amplitude oscillation of the pendulum.[248] Recent precision measurements of *G* by various respected international teams include mutually exclusive values uncharacteristic of a universal constant. The high

level of professionalism of these teams and the significant precautions taken by each to ensure accuracy must be taken into consideration when evaluating the total data set. In 2007, Fixler *et al*. employed the recently-developed method of measuring G using an atom interferometer. Their measurement was well above previous measurements, but by including large error bars they could report that their measurement was 'consistent' with previous measurements of G made by their colleagues.[249] Do the size of these very large error bars have a psychological (i.e., social conformity) component? While the observed disparity in precision measurements of G has been prudently attributed to unexplained experimental errors, it is also possible that an unmodeled property of gravitation is responsible. The experimental results strongly suggest that the gravitational field is sourced from quantum interactions that scale with mass yet have other dependencies, so that G is not a universal constant as conventional wisdom assumes.

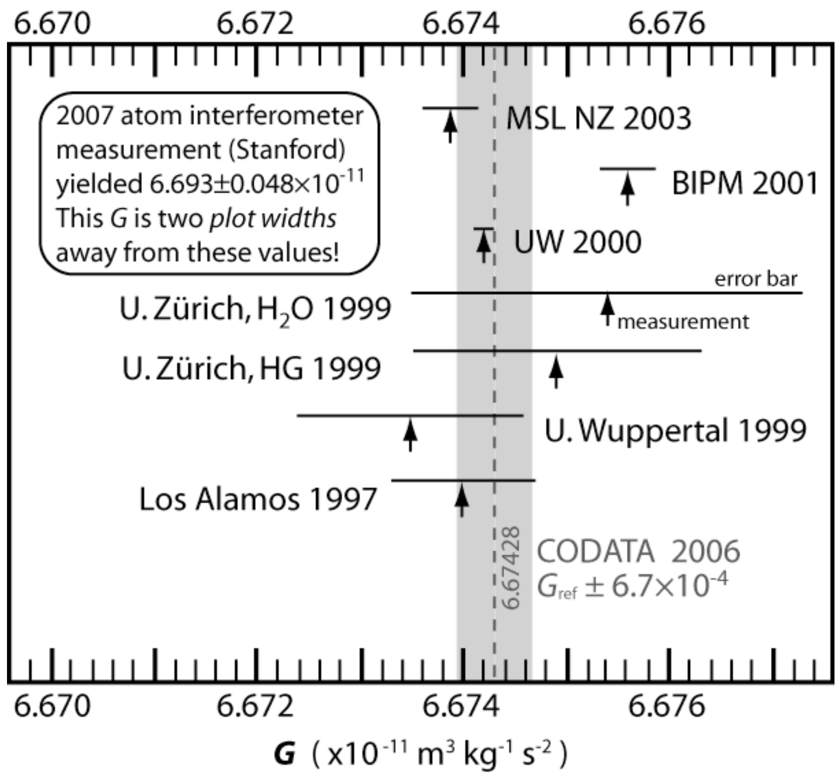


Figure 93 | Recent precision measurements of G.

If the observed disparity in the measurements of G is not due to experimental error, the measurements imply that some variable property of the source masses in the different experiments caused a small but measurable difference in their gravitational field strength per unit mass. The major variable between experiments is the material composition of the source mass, yet according to over three centuries of conventional wisdom in physics, the idea that this might measurably affect the gravitational field strength of a source body and thus the measured value of G is preposterous. However, progress in science has always been based on subsequent empirical verification of what initially seemed a preposterous idea.

$$v_{rms} = \sqrt{\frac{3kT}{m_n}} \tag{121}$$

The internal temperature of the Sun is estimated to be about 15 million degrees Kelvin. This correlates to an easily quantifiable average nucleon velocity within the plasma on the order of 6×10^5 *m/s* (0.2% *c*) per Eq. (121). The associated per nucleon momentum energy (*pc*) within the plasma is then about 1.9 MeV, or about 0.3% of the momentum energy produced by quark confinement. This result implies that any

significant variations in the temperature of a star over time will produce small variations in its gravitational field strength that are certain to affect the ephemerides of orbiting bodies. As concerns the laboratory, the difference in the calculated per nucleon momentum energy produced by a cooled source mass at about 10° K and the identical mass at room temperature (295° K) is about 6.9 keV, which implies that the cold mass can be expected to yield a value of G that is about 1 part in 10^5 less than the warmer mass.

36. UNIFICATION OF FORCES

It should be clear at this point that the nuclear strong force and gravitation are the identical phenomena (spacetime geometry in the context of wave mechanics) manifesting at different length scales. There are no quantized particles involved. As Einstein asserted, gravitation is indeed a pure field, rather than a force mediated by particle exchange. Demonstrating his bold physical insight, and foreseeing a unification of gravitation and the strong force, in 1919 he stated,

> …there are reasons for thinking that the elementary formations which go to make up the atom are held together by gravitational forces.[250]

"Quantum gravity" describes the long-standing attempt to provide a synthesis between what are currently recognized as the four fundamental forces: electromagnetism, the weak force, the strong force and the gravitational force. The standard model of particle physics purports that all of these forces are exchange forces mediated by a distinct fundamental particle. The incontrovertible existence of the *p*-wave strongly suggests that this is a false paradigm as concerns the strong force and gravitation.

On 25 August 2008, Jenkins *et al*. posted to the arXiv what is certain to become one of the most revolutionary discoveries of our time in experimental physics. "Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance" (astro-ph 0808.3283) is based on reliable nuclear decay data acquired over a five-year period (1981–1986) at Brookhaven National Laboratory and corroborating data taken over a fifteen-year period (1983–1998) at PTB in Germany.

> Unexplained periodic fluctuations in the decay rates of ^{32}Si and ^{226}Ra have been reported by groups at Brookhaven National Laboratory (^{32}Si), and at the Physikalisch-Technische-Bundesandstalt in Germany (^{226}Ra). We show from an analysis of the raw data in these experiments that the observed fluctuations are strongly correlated in time, not only with each other, but also with the distance between the Earth and the Sun.

The authors suggest that the observed correlation between nuclear decay rate and Earth's orbit may involve variations in the fundamental constants or seasonal variation in the solar neutrino flux. However, both of these hypotheses seem unlikely. Another hypothesis suggested by this empirical observation is that there exists some deep connection between the binding force operating in the atomic nucleus and the binding force of gravity.

37. RECAPITULATION

Since the dawn of humanity, the dominant form of human communication has been narrative, while impersonal technical presentation of facts is a new behavior that only become prevalent in the latter half of the previous century. One need only track the historical attendance of a major international scientific meeting (e.g., the *Annual Meeting of the American Physical Society*) or the number of scientific articles published per month worldwide to appreciate this. In the first decade of the 21st century, the vast majority of humanity still has no facility or experience with the latter form of communication, let alone the rigors of higher mathematics. Even a large majority of the socioeconomic elite in technically developed countries are functionally illiterate as concerns modern science. Present trends do not show that this is likely to change in the near future. This being the case, modern science includes the social phenomenon of a population of committed "believers" (including most university students) who conform to the edicts of an elite class of leaders due in large part to the social benefits of being an acolyte. Because the greater population of humanity at the present time, including scientific professionals, tend to *believe* whatever they are told by scientific pundits, from a social perspective science is not far removed from a kind of religion. For example, very few people (including most technical professionals such as engineers and biologists) have any familiarity with cosmology other than what they may read in the popular literature or view on televised

scientific documentaries. For at least the last two decades, with rare exception, no expert in the field having significant public visibility has seriously suggested that the Big Bang theory could be incorrect. On the contrary, the standard cosmological model has been taught to students and the lay public in the form of a kind of catechism around the *a priori* interpretation of the cosmological redshift as evidence of an expanding Universe. One exception is a statement by Simon Singh during a 19 February 2005 interview on National Public Radio in the USA. The interview concerned his book, released in October 2004, entitled *Big Bang: The Most Important Discovery of All Time and Why You Need to Know About it*.

> Oh, it could be wrong, that is one of the interesting things about science, that you never know anything for certain — and when the Big Bang was first proposed it was a maverick, outlandish theory that nobody believed in.

Dr. Singh has a Ph.D. in physics from Cambridge University, has worked at CERN, and is an acclaimed British author, journalist and TV producer specializing in science and mathematics. It is remarkable that such an objective matter-of-fact statement could come from an author talking about this particular book. Compare his statement to a contrasting one by Alan Guth of M.I.T. in the 2007 History Channel television series, *The Universe* (see 0:03:47 of the episode *Beyond the Big Bang*). As Guth is celebrated for inventing inflation in an attempt to rescue the Big Bang theory, his assessment is perhaps tainted by personal interest.

> Right now I'd say the Big Bang theory is a solid part of science as we understand it. Ahh, anybody who doesn't accept it *is* regarded by most of the people in the community as essentially a crackpot.

Because few people have the time or resources to personally investigate and verify scientific claims, *personal integrity* is of ultimate importance in science. It is an illusion that good science promulgates exclusively on the merits of impersonal technical support of scientific narrative in the form of predictive models, mathematics, experiment and analysis. Good science is just as dependent on good leading scientists in a moral sense as on good scientists in a technical sense. Accordingly, the American Physical Society (APS) *Guidelines for Professional Conduct* includes the following paragraph.

> Each physicist is a citizen of the community of science. Each shares responsibility for the welfare of this community. Science is best advanced when there is mutual trust, based upon honest behavior, throughout the community. Acts of deception, or any other acts that deliberately compromise the advancement of science, are unacceptable. Honesty must be regarded as the cornerstone of ethics in science. Professional integrity in the formulation, conduct, and reporting of physics activities reflects not only on the reputations of individual physicists and their organizations, but also on the image and credibility of the physics profession as perceived by scientific colleagues, government and the public. It is important that the tradition of ethical behavior be carefully maintained and transmitted with enthusiasm to future generations.[251]

We live in a time in which major corrections in the physical sciences seemed to be a thing of the past. It was tacitly assumed that the foundations of modern physics were firmly established over the course of the 20th century. The preceding decade has been described as "a new era of precision cosmology" with the popularized assumption that empirical measurements have already reliably confirmed the framework of the standard cosmological model beyond reasonable doubt. However, in a brief and straightforward technical discussion, *Sections 2–3* of this dissertation show the substantial difference between the predictions of the standard model and reliable empirical data, while previewing the accurate predictions of a completely new and fundamentally different cosmological model.

The special theory of relativity arguably provides the most fundamental and comprehensive foundation for all of modern physics and (prior to reading this book) virtually every professor of physics at a modern university would assume that everything that there is to know about the theory was properly understood and already described in various textbooks. Yet, *Sections 4–7* herein point out that something as simple and fundamental as special relativity was inadequately understood in the past due to the conventional emphasis on algebraic equations describing the relative tick rate of ideal clocks rather than the underlying geometry of their tick intervals as measured in different directions in spacetime. It has been made a simple and obvious fact that future textbooks on the topic of special relativity must discuss the subject in the primary context of the geometry of time in spacetime, rather than the less transparent and edifying subordinate context of the algebraic Lorentz transformation equations.

Based on the geometric foundations of special relativity established by Hermann Minkowski in 1908, *Sections 8–14* provide a simple and comprehensive cosmological model. This model abandons the interpretation of the cosmological redshift as an expansion of space in favor of a relativistic effect produced by the uniform geometry of a finite and boundaryless Universe with a large-scale homogeneous isotropic distribution of matter. It implies a precisely quantifiable relationship between the observed relativistic time dilation of an ideal clock and its relative cosmological distance from an observer at rest with respect to this clock in a Universe with a radius that remains fixed over time. In addition to this redshift-distance relationship, the new model, which incorporates the concept of relativistic geometric cosmic time, provides equally precise redshift-volume and redshift-luminosity relationships with no free parameters that might be manipulated to fit mathematical predictions to astrophysical observations.

The theoretical theta-z relationship of the new model, which is just the inverse of the redshift-distance relationship, provides a startlingly perfect match to the empirical data from SDSS as shown in Fig. (9). Similarly, the redshift-volume relationship expressed as the differential (dV/dz) provides a curve that is consistent with the empirical data from SDSS as shown in Fig. (23). In both cases, the conventional theoretical model based on the Hubble expansion interpretation of the redshift yields predictions do not even come close to correlating with empirical observations [Fig. (7) and Fig. (8)].

Science is a disciplined way of thinking that seeks natural explanations for all observed phenomena, although it may not always be able to do so. "Natural" implies that the explanation must rest on a body of self-consistent rational knowledge. In 1998 it was first reported that a graph of the relative luminosity of Type Ia supernovae as a function of redshift produced a curve with increasing slope. The original purpose of the astronomical investigations was to measure the anticipated decrease of this curve's slope with increasing redshift, showing the gradual slowing of the Hubble expansion due to gravitational attraction. Observing the opposite trend in the graph, the resulting interpretation of the data was simply the opposite of the originally anticipated interpretation. However, this interpretation necessitates the *ad hoc* invention of "dark energy," a concept that is inconsistent with and even contrary to the entire body of known physical law. Consequently, "dark energy" is really a euphemism for "supernatural force" and is nothing more than pseudo-science in the absence of a rational explanation for the observed unexpected trend in the slope of the redshift-luminosity relationship for Type Ia supernovae.

The real world of rational science precludes handwaving to describe new empirical observations in order to preserve old ways of thinking. A decade ago, the discovery of the increasing slope for the Type Ia supernovae redshift-luminosity graph initiated a *scientific crisis*. Those who have endorsed "dark energy" as an explanation for the graph in order to resolve this crisis effectively abandoned scientific principles. "Dark energy" is meaningless in the context of science because it cannot be theoretically correlated to any other aspect of physical reality. There is no difference whatsoever between alleging that "dark energy" initiated a sudden inexplicable accelerated expansion of the Universe and alleging that the observed phenomenon is a miraculous act of God. Both are equally unacceptable in the context of science, because neither explains anything in relation to anything else. In contrast, the graph in Fig. (28) is a prediction that rests on empirically verified first principles and fundamental mathematics (geometry).

The practice of science requires various competing models of empirical phenomena to be considered and in all cases we have to ask, "What is the more likely explanation?" — The secular spindown of rotating astrophysical bodies including pulsars, stars and planets is observed. Similarly, Phobos and Io are each observed to be spiraling in towards their respective host planet. These observations imply a phenomena of radiative energy transfer related to the gravitational field. Previously uncorrelated to this ubiquitous energy transfer phenomenon in dynamical gravitational systems, we observe a ubiquitous microwave radiation. This radiation is noticeably warmer where there is greater dynamical gravitational activity and colder where there is less. The rotating disk of the Milky Way Galaxy exhibits an unexplained excess of microwave radiation and, based on analysis of WMAP data, there is reason to believe that the solar equatorial plane, inclined 7-degrees to the Ecliptic, exhibits a similar excess microwave temperature. Lastly, when we look out into the Cosmos with our instruments, we observe a relationship between the distance to a galaxy and a redshift of its source light that has an increasing slope. — Which of the following two explanations for *all* of these observations is the more plausible of the two?

Conventional explanation of observations:

About 13.7 billion years ago there was nothing. Time, space and energy did not exist. A moment later, time came into being as part of the unified fabric of spacetime and the entire baryonic mass-energy of the Universe (on the order of 10^{80} nucleons) emerged from a point of infinite density. This singularity in space and time defies the known laws of physics. Inexplicably, the Universe initially expanded by a factor of 10^{50} in $\sim 10^{-32}$ second at ultra superluminal speed and then it suddenly slowed down. Within the first billion years of its existence, galaxies of all different shapes and sizes formed simultaneously from the local gravitational collapse of protogalactic clouds composed primarily of hydrogen. The Milky Way Galaxy as well as every other observed galaxy formed at about the same time. The expansion of the Universe continued to decelerate due to the gravitational attraction of its mass content. For an inexplicable reason and employing some inexplicable phenomenon that is contrary to the known laws of physics, the decelerating expansion of the Universe suddenly switched to accelerating expansion. The relativity of time that is measurable in the laboratory applies locally, but it does not apply cosmologically. Consequentially, there exists a kind of virtual Newtonian absolute clock that somehow exists external to physical spacetime providing a "God's eye view" of time. This special clock measures the age of the entire Universe treated as a single object traveling through time. The relativity of time internal to the Universe does not apply to this absolute cosmological clock. All intelligent beings now find themselves living in a Universe in which every astrophysical object or conglomeration of these objects, including galactic superclusters, have an intrinsic age of not more than about 12 billion years, which is less than three times the geologic age of the Earth. After a complex process in which the foreground signal is removed according to subjective criteria, the cosmic microwave background radiation is interpreted as the leftover heat from the alleged Big Bang.

Alternate explanation of observations:

Just as the principles of relativity destroy the Newtonian concept of absolute time, they also destroy the Newtonian concept of a gravitational equipotential surface, which is easily demonstrated by a gedanken experiment resting exclusively on first principles. Time is a local internal property of the Universe and time even as measured by two ideal clocks at the same Newtonian gravitational potential and at relative rest has a relativistic relationship; to some degree of measurement resolution, no two ideal clocks in the Universe are synchronous. This phenomenon causes measurable relativistic clock effects for GPS satellite signals, other spacecraft signals and astrophysical radiation (*Sections 15–23*). It also causes the observed cosmological redshift. The relationship between the relative cosmological distance and the relative tick rate of an ideal clock (unaffected by relative motion or a local gravitational field) arises from the simple geometric foundations of the special theory of relativity and is precisely defined with no free parameters. This relationship yields an increasing slope for the graph of redshift versus apparent magnitude of a standard candle that deceptively suggests acceleration, if the redshift is interpreted as cosmic expansion. At a finite distance from an observer the cosmological time dilation redshift is infinite, creating a cosmological redshift horizon. Correlated with secular spindown and orbit decay, dynamical gravitational systems emit quantized "gravitational radiation" in the form of electromagnetic radiation, primarily in the microwave region of the spectrum. The equatorial planes of Solar System bodies and the plane of the Milky Way are associated with a measurable excess microwave temperature that is of the same phenomenological origin as the excess microwave temperature associated with distant galaxy clusters (*Section 24*). The concept of geometric time simplifies and improves understanding of the general theory of relativity. Consequently, a more accurate general model of black holes emerges; it is understood that white holes, which emit mass-energy absorbed by a remote correlated black hole, are also implied by the theory as first intuited by Einstein and Rosen in 1935. The phenomenon of a white hole, allowing mass in a limited local region of space to increase over time (with a commensurate decrease elsewhere), implies a new model of galaxy evolution, explains the observed abundance of the light elements, explains the flat rotation curves of spiral galaxies without assuming the existence of "dark matter," and allows the Universe to exist as an eternal dynamical equilibrium process (*Sections 25–28*).

The Big Bang theory assumes a single "moment of *Creation*" (G. Lemaître) for the entire Universe. Historical record shows that it was this *a priori* idea authored by the young Catholic priest to which

empirical observations were then initially fit with grotesque error ($H_0 = 500$ *km/s/Mpc*) by Edwin Hubble. Hubble met with Lemaître at Mt. Wilson observatory in 1925, yet failed to acknowledge Lemaître's obvious influence on Hubble's lauded *apparent* empirical discovery of an expanding Universe in 1929.

> [Edwin Hubble] was a strong and gifted athlete, charming, smart, and immensely good-looking—"handsome almost to a fault," in the description of William H. Cropper, "an Adonis" in the words of another admirer. According to his own accounts, he also managed to fit into his life more or less constant acts of valor—rescuing drowning swimmers, leading frightened men to safety across the battlefields of France, embarrassing world-champion boxers with knockdown punches in exhibition bouts. It all seemed too good to be true. It was. For all his gifts, Hubble was also an inveterate liar.[252]

Given Hubble's habit of telling lies about self-aggrandizing exploits that never occurred, his almost certain plagiarism of Lemaître's biblically-inspired idea of an expanding Universe is not surprising. Furthermore, it is doubtful that Lemaître would have developed the same theory that guided Hubble's interpretation if the priest had come from a different cultural background from the one which prompted him to profess in a 1922 essay his belief that the Universe originated "as *Genesis* suggested it." From a scientific perspective, the Big Bang theory stands out due to its lack of self-consistency, cherry-picking of empirical observations, interpretation of observations at its convenience, and incorporation of incredible *ad hoc* phenomena in order to preserve the narrative (i.e., a single moment of total cosmic creation). It is not unreasonable to say that the Big Bang theory has more to do with perpetuating an anachronistic religious idea (Hebrew biblical creationism) than with disciplined scientific analyses. If this is indeed true, then it is important that this be generally recognized, for religious ideas are generally protected from scientific criticism and are free to rest on supernatural phenomena that require no rational explanation. Inflation and "dark energy" are intellectual inventions of convenience cloaked in the vernacular and intellectual aura of modern physics, yet they are effectively indistinguishable from the supernatural.

The Doppler shift of a receding sound source is a commonly experienced physical phenomena. Similarly, if one inflates a uniformly polka-dotted spherical rubber balloon, it is readily apparent that a dot two units away from a reference dot recedes at twice the speed of a dot only one unit away. The Hubble interpretation of the cosmological redshift is a simple extrapolation of these experientially-based ideas. The idea that the cosmological redshift is unrelated to a recessional motion of distant galaxies, but is rather a relativistic time dilation based on large-scale cosmic spacetime geometry, rests on a more abstract and less instinctive foundation. The remarkably simple but profound idea of geometric cosmic time shown in Fig. (20) cannot be conceived or understood without first fully understanding the physical implications of Minkowski's formal mathematical model of Einstein's relativity theory; the *geometry of time* implied by relativity was previously inadequately understood. It is also necessary to preconceive of the Cosmos as having a finite boundaryless volume of three-dimensional space, an experientially inaccessible geometry that is difficult to imagine without some training in mathematics. There is nothing in experience that can lead one to the understanding that time and space have a geometric relationship in a physical sense or that "*time becomes space*," as Feynman stated so simply, directly and elegantly.

Based on a number of assumptions, the conventional interpretation of observations is that the apparent brightness of a standard candle decreases by a factor of 100 (i.e., +5 magnitudes) over each decade increase in cosmological redshift. This interpretation is consistent with an assumed linear relationship between redshift and distance and the inverse square law applicable to dispersion of photons from an isotropic source over the surface of a Euclidean sphere. These constraints correlate to simplistic direct experience of phenomena, just as the idea of a 'flat' Earth made sense to ancient thinkers, yet these constraints cannot be valid for a finite boundaryless spacetime Universe. Moreover, a linear redshift-distance relationship implies a 100-fold increase in the volume of a differential volume of space of depth Δz over a decade of redshift (e.g., $0.01+\Delta z$ vs. $0.1+\Delta z$). Consequently, in a Universe that is approximately homogenous and isotropic over this range, the farther bin should contain on the order of 100 times as many galaxies as the closer bin. Recent galaxy redshift surveys (e.g., SDSS) are inconsistent with this prediction, as well as the theta-z relationship implied by the Lemaître-Hubble model [Fig. (7) and Fig. (8)].

Various prior redshift-distance measurements, in particular SNe Ia redshift-luminosity measurements, allegedly verify a linear relationship between redshift and distance (i.e., the "Hubble Law"). However, the unmistakable huge discrepancy between this model and empirical data revealed in the Fig. (7) and Fig. (8)

graphs represents dissimilar information. It is impossible that both sets of data (one supporting the model and the other overthrowing the model) are simultaneously correct, so the question arises as to which of the data sets (the redshift surveys or the alleged average slope of the SNe Ia redshift-luminosity curve) is a more reliable reflection of objective physical reality.

The data supporting the conventional cosmological model is immediately suspect as it was produced in support of a pre-existing theoretical model that was generally assumed to be infallible. It is arguably the case (and is likely a historical fact) that most papers written in the past half-century and submitted to a peer-reviewed journal that questioned the linear redshift-distance relationship were summarily rejected. Moreover, academics (especially young graduate students) understand that permanent career limitations are likely to result if an attempt is made to communicate thinking that deviates too far from the status quo. Consequently, few papers critical of the standard model would have been produced, while thousands of papers supporting the Big Bang theory obviously flourished in the literature. The Big Bang paradigm was arguably so dominant in the past that an SNe Ia redshift-luminosity curve or any other astrophysical measurement that did not conform with the standard model was effectively unpublishable.

In contrast to attempts to measure the redshift-distance relationship for galaxies, galaxy redshift surveys such as SDSS are not influenced by the standard cosmological model, with the exception of model-influenced selection criteria. Spectroscopic redshifts as well as the Petrosian radius are direct empirical measurements that are not subject to subjective manipulation. Additionally, the very large number of individual measurements and the obvious correlation between the SDSS and the 2dF galaxy redshift survey data (obtained in different hemispheres) ensure that the observed statistical trends are physically real. A conclusion that can be drawn, if prior measurements of the redshift-distance relationship are indeed inconsistent with the latest redshift surveys, is that these prior measurements must be erroneous. Consequently one must conclude that the “Hubble Law” has no correlation with physical reality.

Richard Price points out that pre-Copernican astronomers engaged in absurd intellectual gymnastics for centuries to preserve the religiously-motivated paradigm of an Earth-centered Universe, although it should have been obvious that observations did not support this assumption (p. 11). For the past eight decades, astrophysicists and cosmologists have engaged in even more absurd intellectual gymnastics in order to preserve the Western cultural heritage originating in the *Book of Genesis* that the entire Universe and even time itself were miraculously created in a single moment from nothing. As this religious myth originated with ancient Hebrew tribesmen who were equally ignorant of science as modern primitives (e.g., Kalahari Bushmen) it is unreasonable to suppose that it has any scientific merit. At face value, the Big Bang theory is utterly absurd. — The purported initial space-time singularity is absurd. The idea of inflation is absurd. The interpretation of SNe Ia observations as a sudden accelerating expansion is absurd, as is invoking the *ad hoc* idea of “dark energy” as the apparent cause. The idea that no structure in the Cosmos is older than about 13 billion years and all galaxies are of approximately the same age is also absurd (p. 36). The Big Bang theory must eventually be regarded as having been even more unlikely than the astrophysics of Ptolemy, which was long thought to successfully account for the observed motions of the heavenly bodies. That the Big Bang theory has for decades been considered a cornerstone of modern science by virtually the entire academic establishment suggests that some feature of the “post-modern” culture of the 20th century led to an astounding systemic decline in the quality of thinking.

The objective quality of human endeavor (e.g., a work of art) is best determined by taking that thing out of current subjective social and cultural context. A product of quality thinking perseveres in quality over an indefinite amount of time. For example, it is entirely possible for a 21st-century mathematician to begin a lecture by saying that some new mathematical concept is motivated by the work of Archimedes. Similarly, even in several millennia, discovery of a Mozart composition or a preserved work of art by Michelangelo would be immediately recognized as a find of great value. Why is this so? Can the same be said of what typically passes for modern art of our era and what has been recently touted as leading edge modern physics (e.g., string theory)? Perseverance of quality physics or any other product of intellectual creativity arises from the same intangible source as the perseverance of a mathematical proof; changing fashions are irrelevant. A superior culture is quick to recognize and value quality thinking, while an inferior culture values fashion or political expediency above objective reality.

> On the other hand, if string theorists are wrong, they can't be just a little wrong. If the new dimensions and symmetries do not exist, then we will count string theorists among science's greatest failures, like those who continued to work on Ptolemaic epicycles while Kepler and Galileo forged ahead. Theirs will be a cautionary tale of how not to do science, how not to let theoretical conjecture get so far beyond the limits of what can be rationally argued that one starts engaging in fantasy. – Lee Smolin [253]

Departing from the main theme of cosmology, the discussion in *Sections 30–36* begins with a revealing discussion of relativistic energy. This discussion rests on the principle of energy conservation in the context of the mathematical fact that the principles of relativity imply that relativistic energy must necessarily be represented by a complex number [Eq. (103)]. The conventional belief that energy must be represented by a real number because it is an observable and that mass energy (ignoring potential energy) represents "total energy" (implied to mean the complete relativistic energy budget) is shown to be naïve. Consideration of the well-known relativistic energy-momentum equation (99) makes it clear that mass energy is generally a subset of the total systemic relativistic energy, which is the linear sum of the independent rest energy and the momentum energy magnitudes [Eq. (109)]. This is made patently and intuitively clear in Fig. (85).

First principles imply that the excess momentum energy of a material particle that is not incorporated in its relativistic kinetic energy [Eq. (110)] must manifest as a standing wave phenomenon. The wavelength (h/p) and phase velocity (c) of this momentum wave or "p-wave" are similarly defined. As the theoretical description of the p-wave rests on first principles, it is manifestly a physical phenomenon, yet for more than a century it remained totally unrecognized. Like the simple idea of a heliocentric Solar System, the p-wave is completely obvious in hindsight, yet it remained unknown to succeeding generations of physicists who were blinded by the apparent "success" of a more complicated existing conventional model that gave the false appearance of successfully describing empirical observations.

The fundamental physical interpretation of general relativity, which must be scale-independent, is that the presence of energy causes a distortion in the geometry of spacetime. A synthesis of this idea with the qualitative and quantitative description of the p-wave implies a concentric periodic spacetime distortion (i.e., a *periodic field* at quantum scale) produced by any oscillating subatomic particle. The distinction between a subatomic particle and its spatially distributed p-wave field with phase velocity c is similar to the distinction between a macroscopic mass and its gravitational field. Comparing qualitative diagrams of the two fields, the only difference between them is scale; the p-wave field has a typical wavelength on the order of 10^{-15} meter, while a gravitational field produces a single large-scale wave in spacetime of arbitrary wavelength. As interference of decoherent p-waves will produce a composite wave, it is apparent that the quantum unit of the gravitational field is the p-wave. The p-wave is a simple and elegant solution to the synthesis between quantum mechanics and general relativity, just as a heliocentric Solar System was a simple, elegant and (in hindsight) obvious solution to celestial mechanics in the 16th century.

The p-wave resolves the wave-particle duality conundrum by unambiguously differentiating between particle and wave manifestations. As was suspected by de Broglie, Einstein, David Bohm, Eugene Wigner and J. S. Bell, p-wave interference provides a "guiding field" that directs the trajectory of a particle from a double-slit barrier to the target screen [Fig. (89) and Fig. (90)]. As the double-slit diffraction pattern can be explained by p-wave interference, complementarity is exposed as an unphysical extraneous concept.

Because the p-wave is subject to a Doppler shift, the effective wavelength of relativistic electrons is predicted to deviate from h/p. This prediction differs from conventional quantum theory because the de Broglie matter wave is not subject to a Doppler shift. This differentiating prediction between the two theories allows for an empirical test using diffracted relativistic electrons to determine if conventional quantum theory is indeed incorrect in that it assumes the dubious concept of complementarity while failing to recognize the momentum wave phenomenon.

The bound quarks of a nucleon each produce a p-wave with known wavelength and energy according to the Heisenberg uncertainty principle. The core of this wave implies a binding potential with a sharp boundary and a radius on the order of 10^{-15} meter. Interference of p-waves sourced from multiple mutually bound nucleons in a typical atomic nucleus imply a composite spacetime waveform with a sharp external

boundary having a radius on the order of 10^{-14} meter and an internal fine structure of isolated potential wells forming a nuclear shell structure with quantized energy levels [Fig. (91)]. Although considerable additional work is required to provide more detail, all of the features of the nuclear strong force can be modeled by the *p*-wave, which suggests that the concept of an exchange force mediated by "gluons" is extraneous.

Interference of decoherent *p*-waves sourced by all the nuclei of a source mass implies a binding force of unlimited range many orders of magnitude smaller than that represented by the core wave. It is then reasonable to suppose that the gravitational field, which any metric theory of gravity models as a large-scale wave in spacetime, is a composite of *p*-waves primarily sourced from quark confinement and thus predominantly though not exclusively dependent on mass. Thus, the strong force and gravity are envisioned to be the identical phenomenon (spacetime geometry) observed at different scales. Because composite nucleon momentum and composite atomic momentum contributes to the *p*-wave energy radiated by a source mass, chemical composition and even temperature of a source mass are predicted to cause measurable changes in the gravitational coefficient (i.e., what Isaac Newton assumed was the universal constant G). Thus, the idea that the quantum source of the gravitational field is directly correlated to the internal momentum of the source mass is in principle a testable hypothesis.

38. CONCLUSION

Carl Sagan's *Cosmos* was the most popular and widely viewed public television series in PBS history. The series made its debut in the United States on 28 September 1980 and it is estimated that over 500 million people in over 60 countries have seen it. The companion book topped the *New York Times* non-fiction bestseller list for well over a year.[254] In this educational scientific television series, Sagan stated,

> We humans long to be connected to our origins, so we create rituals. Science is another way to express this longing. It also connects us with our origins, and it too has its rituals and commandments. *Its only sacred truth is that there are no sacred truths*. All assumptions must be critically examined. Arguments to authority are worthless.

Similarly, Albert Einstein is reported to have stated, "Unthinking respect for authority is the greatest enemy of truth."[255] Thus, he openly encouraged questioning the sanctity of his own creative ideas.

The key empirical assumption that gave rise to the standard Big Bang cosmological model is that the observed redshift of distant galaxies is similar to a Doppler shift in that it is indicative of a general recessional velocity of galaxies relative to the Milky Way. More fundamental to this assumption is the tenacious instinctual concept of absolute linear time (i.e., a universal "cosmic calendar") that predates Einstein's relativity theory. — Among other innovations, this book has introduced a fundamental change in the way we must think about time in physics, particularly from a cosmological perspective. The naïve idea of a single linear cosmic timeline as shown in Fig. (11), which is based on subjective experience of sequential local events separated by time intervals, is replaced by an objective multidimensional geometry of cosmic time represented by an arbitrary number of distinct local timelines. Indeed, as Alan Lightman surmised in *Einstein's Dreams*, "In this world, time is a local phenomenon." In hindsight, it will seem obvious to physical scientists that relativity implies a multidimensional geometry of time, rather than the notion of a single universal timeline that arises from the typical daily perception of time. However, this simple idea requires a shift in thinking not unlike the historical acceptance of a heliocentric Solar System. In its era, the Copernican Revolution met with strong political resistance, in part because it represented far more than just a new scientific idea; the revelation that the Earth was not the center of the Universe was a fundamental transformation in the 16th-century cultural worldview and it threatened academic reputations.

The abolishment of the Big Bang cosmological paradigm and the scientific recognition of an eternal Universe will likely initiate some kind of 21st-century global cultural transformation, similar to that which occurred in the 18th-century Age of Enlightenment. We now think of the Universe as evolving over time, so what does it mean for ontology when scientific theory supported by empirical evidence implies that the Cosmic Process has occurred over an infinite amount of time? Perhaps it will become palatable for many in the scientific community to begin to believe and to teach that we live in a purposeful and participatory Universe as mystics throughout history have asserted, among them both Johannes Kepler, the author of *Concerning the More Certain Fundamentals of Astrology* (1602), and Isaac Newton, the devoted alchemist.

Isaac Newton is often presented as the father of modern scientific rationalism, but modern accurate biographies based primarily on study of Newton's "secret papers," bequeathed by John Maynard Keynes to Kings College, Cambridge, reveal that Newton's towering intellectual achievements were made in the context of an intense devotion to religious mysticism and the ancient spiritual practice of alchemy.

> In the eighteenth century and since, Newton came to be thought of as the first and greatest of the modern age of scientists, a rationalist, one who taught us to think on the lines of cold and untinctured reason. I do not see him in that light. I do not think that anyone who has poured over the contents of that box which he packed up when he left Cambridge in 1696 and which, though partly dispersed, have come down to us, can see him like that. Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians, the last great mind which looked out on the visible and intellectual world with the same eyes as those who began to build our intellectual inheritance rather less than 10,000 years ago. Isaac Newton, a posthumous child born with no father on Christmas Day, 1642, was the last wonder-child to whom the Magi could do sincere and appropriate homage. – John Maynard Keynes (1942) [256]

While in recent decades there was almost universal acceptance of the Big Bang theory by professional scientific communities who imagined their shared belief system to be based on rigorous analysis untainted by human foibles, a majority of the general population did not share this view.

> Throughout the last decade, national studies found that about a third of US adults are aware of and accept the idea that "the universe began with a huge explosion" (NSB, 2000). A third of Americans overtly rejected this idea, and another third indicated that they did not know whether this construct was true or not. Some of the outright rejection reflects personal religious views.[257]

In the 1850s, William Thomson (a.k.a. Lord Kelvin) extrapolated the laws of thermodynamics to cosmological scale. This introduced the hypothesis, later pursued by Hermann von Helmholtz and William Rankine, that a so-called "heat death" or universal state of absolute zero temperature is a likely if not inevitable final state of the Universe. The later erroneous idea that the Universe must expand forever has essentially the same consequence. Thus, for well over a century, modern science has asserted that mankind exists in a Cosmos that is ultimately hostile to Life. In contrast, enlightened religious philosophy typically holds the Cosmos to be the eternal realm of *Spirit* and consequently of *Life* and *Mind*. If the Universe did not indeed come into being a finite time ago, then clearly the scientific concept of cosmic "heat death" is just another incorrect and narrow-minded anthropomorphism.

In a letter to a friend written near the beginning of the Industrial Revolution, the visionary English poet and artist William Blake (1757-1827) suggested that we must guard against the deceptive and limiting "single vision" of scientific materialism or any other fundamentalism.

> Now I a fourfold vision see,
> And a fourfold vision is given to me;
> 'Tis fourfold in my supreme delight
> And threefold in soft Beulah's night
> And twofold Always. May God us keep
> From Single vision & Newton's Sleep! [258]

Blake's "fourfold vision" integrated artistic creativity ("my supreme delight") loving human relationships ("soft Beulah's night," which refers to the marriage bed), as well as the ever-present interplay between the spiritual and the physical worlds ("twofold Always"). Blake clearly recognized and respected Newton's supreme scientific genius, yet this great poet's inspired and inspirational message was that the physical world that is accessible to scientific inquiry is only a part of reality, not its totality. It is apparent that Blake, who was born thirty years after Newton's death and knew only of the scientist's popularized persona, was actually referring to the materialist zeitgeist instigated by the *Principia*, rather than its author. Expressing the same view from a different perspective, Einstein made the following comment.

> One thing I have learned in a long life: that all our science, *measured against reality*, is primitive and childlike — and yet it is the most precious thing we have.[259]

This wisdom conflicts with the predominant modern scientific philosophy, which maintains that the Universe is a kind of purposeless machine and that what science cannot analyze and measure is not real.

The ideas presented in this book imply that a large portion of 20th-century physics essentially became a kind of popular ideology (i.e., "consensus science"), a general social phenomenon discussed at length in Thomas Kuhn's *The Structure of Scientific Revolutions*. Empirical evidence contradicting that ideology was ignored, conveniently advancing personal agendas instead of leading to doubt and a superior model. Those who have fervently promoted Big Bang cosmology while exhibiting condescending intolerance for critics who openly questioned the validity of the theory have demonstrated an unself-critical attitude that is antithetical to science. Now it is time for them to admit their errors, but this is arguably a healthy lesson in life. Rabbi Sherwin T. Wine gave a speech in New Jersey at the 2003 HumanLight Celebration entitled *The Life of Courage*. In it he stated:

> Realistic living is the courage to acknowledge the truth, even when it is painful. It is the courage to strive for happiness, even when it is unlikely. It is the courage to make necessary decisions, even when there is uncertainty. It the courage to improve the world, even in the face of overwhelming defeat. It is especially the courage to take both the blame and the credit, even when they are embarrassing. Realistic living is the courage to stay sane in a crazy world. The sun requires no courage to rise in the morning, to shine in the day, to die in the evening. But we, living, breathing, passionate people, we do.[260]

The H*umanist Manifesto I* of 1973 opens with the following statement.

> Today man's larger understanding of the universe, his scientific achievements, and deeper appreciation of brotherhood, have created a situation which requires a new statement of the means and purposes of religion. Such a vital, fearless, and frank religion capable of furnishing adequate social goals and personal satisfactions may appear to many people as a complete break with the past. While this age does owe a vast debt to the traditional religions, it is nonetheless obvious that any religion that can hope to be a synthesizing and dynamic force for today must be shaped for the needs of this age. To establish such a religion is a major necessity of the present. It is a responsibility that rests upon this generation. We therefore affirm the following:
>
> **FIRST**: Religious humanists regard the universe as self-existing and not created.[261]

Fourteen additional succinct tenets follow (see the URL in the reference). If the authors of this document were entirely correct about the foremost point in their manifesto, in spite of tremendous social pressure to embrace as fact the popular Big Bang theory of sudden cosmic creation, the ideas in this manifesto may well compare favorably to scientific materialism, which now typically dominates the philosophy taught by institutions of higher learning. That philosophy contributed to 20th-century beliefs and behaviors that brought about industrialized warfare, massive environmental destruction, unchecked population growth, economic turmoil, and a modern global resurgence of unreasonable religious fundamentalism. The other fourteen points put forward to help guide human conduct are certainly worthy of respectful consideration by every world citizen, regardless of their existing personal religious or philosophical beliefs.

Famed mathematician Alfred North Whitehead was a proponent of "Process Philosophy," a conviction that experiential process rather than measurable substance defines reality. In a remarkable book, *Adventures of Ideas* (1933), he made a critical point concerning the impact of cosmology.

> When we examine [the intellectual agencies involved in the modification of epochs] we find a rough division into two types, one of general ideas, the other of highly specialized notions. Among the former, there are the ideas of high generality expressing conceptions of the nature of things, of the possibilities of human society, of the final aim which should guide the conduct of individual men. In each age of the world distinguished by high activity, there will be found at its culmination, and among agencies leading to that culmination, some profound cosmological outlook, implicitly accepted, impressing its own type on the current springs of action. This ultimate cosmology is only partly expressed, and the details of such expression issue into derivative specialized questions of violent controversy. The intellectual strife of an age is mainly concerned with these latter questions of secondary generality which conceal an agreement upon first principles almost too obvious to need expression, and almost too general to be capable of expression. In each period there is a general form of the forms of thought; and, like the air we breathe, such a form is so translucent, and so pervading, and so seemingly necessary, that only by extreme effort can we become aware of it.[262]

Ask anyone, "How old is God?" Even if the person thinks of God from a secular perspective, the typical answer, is "God does not have an age; the very *idea* of God transcends finite time." Within a few years, the same question concerning the Universe posed to any educated scientist should result in a similar answer. The Universe is evidently a collective *process* (not an object) that does not have an age; only in reference to a local ideal clock that records the sequential time coordinates of local events does the physical concept of 'age' have significant meaning. Some may find it ironic that the activity we call *Science* suggests a humble attitude toward developing human understanding of the Universe and therefore a time-transcendent Creative Source. Indeed, the word "theory," which is an essential element of modern science and physics in particular, has its roots in the Greek "theos" (God) and "ora" (to look); thus the semantic root of the verb *to theorize* implies "to look for God" or "to look at God."

Dating back to the youthful Georges Lemaître, many have associated the Big Bang theory with the biblical *Genesis*, most famously including Pope Pius XII (1939–1958) according to a speech given in November 1951, *The Proofs For The Existence Of God In The Light Of Modern Natural Science*.[263] However, judging by its opening paragraph, *Genesis* is clearly an allegorical story that relates exclusively to our planet and galaxy (i.e., "heaven" as observed by the ancients), rather than the entire Cosmos, and one that incorporates confused unscientific statements conflicting with empirical facts. From *Torah*:

> IN THE BEGINNING GOD created the heaven and the earth. And the earth was without form and void; and the darkness was on the surface of the deep. And the wind from GOD moved over the surface of the waters. And GOD said, Let there be light: and there was light. And GOD saw the light, that it was good: and GOD divided the light from the darkness. And GOD called the light Day and the darkness he called Night. And there was evening and there was morning, one day.[264]

Moreover, *Genesis I* maintains that God created the Sun, the Moon and even the stars in the sky on the fourth day after first creating the sea, the land and plant life. Continuing from the *King James Bible*:

> And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so. And God called the firmament Heaven. And the evening and the morning were the second day.
>
> And God said, Let the waters under the heaven be gathered together unto one place, and let the dry land appear: and it was so. And God called the dry land Earth; and the gathering together of the waters called he Seas: and God saw that it was good. And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself, upon the earth: and it was so. And the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after his kind: and God saw that it was good. And the evening and the morning were the third day.
>
> And God said, Let there be lights in the firmament of the heaven to divide the day from the night; and let them be for signs, and for seasons, and for days, and years: And let them be for lights in the firmament of the heaven to give light upon the earth: and it was so. And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: he made the stars also. And God set them in the firmament of the heaven to give light upon the earth, And to rule over the day and over the night, and to divide the light from the darkness: and God saw that it was good. And the evening and the morning were the fourth day.

It is immediately clear to anyone with even an elementary scientific education that in these first few paragraphs of the *Old Testament*, the order of the alleged supernatural creation is categorically incorrect; plants obviously require a *pre-existing* "greater light to rule the day" (i.e., the Sun). This is because ancient Hebrews wrote this story attempting to explain their observed world from a confused primitive perspective thousands of years ago. The visibility of the Sun was correlated with daylight, but the causal relationship was not understood. While select passages in the Bible and similar texts may contain timeless wisdom concerning human life in limited contexts, idealizing the Bible as an infallible authority on reality is as irresponsible and hazardous as a doctor today similarly idealizing 18th-century medical textbooks. Yet, why do so many people today still maintain anachronistic irrational dogmatic religious beliefs? Arguably it is in large part because they have not been given a viable alternative context for their innate religious feelings that integrates these ubiquitous feelings with the modern scientific perspective.

> Myth is a way human beings relate to their universe. What exactly is a myth? In his last book, *The Inner Reaches of Outer Space*, mythologist Joseph Campbell made the passionate argument that what our society most desperately needs is a new story of reality for all of us—not just some chosen group. The story must demonstrate humanity's connection to all there is, yet be consistent with all we know scientifically. What he was longing for was a new myth, but he knew that no one can simply create a myth, any more than they can "predict tonight's dream." A myth, he said, must develop from the life of a community. He hoped inspiration for such a story might come from physics.
>
> …
>
> The narrow, local kind of mythic explanation that sufficed when cultures rarely mixed will never work in the emerging global culture. We now need myths that are not only scientifically believable but allow us to participate—all of us. To experience the human meaning of modern scientific cosmology, and to turn it into a working cosmology—a meaningful universe—in which we feel like participants, our culture will gradually have to transform it into myth. However, mythmaking is no longer a purely imaginative, spiritual endeavor. Today the leeway for speculation about the nature of time, space, and matter has narrowed. Now that we have data, whole classes of possibilities have been ruled out, and science is closing in on the class of myths that could actually be true.[265]

Following is an excerpt from an interview of John Mather and George Smoot by Adam Smith.

> [nobelprize.org – video time code of Mather and Smoot Interview; 30:52/33:25] [266]
> *Mather*: Life is just as mysterious now as it ever would have been.
>
> *Smith*: And moving on to the unexplainable, for the last question Vijaya Krishna Giravaru from California wants to know what you would tell curious kids if they asked you, "What happened before the Big Bang?" (laughter)
>
> *Mather*: I'd say that is a really good question and science has not answered the question. We don't know if it is even a meaningful question because we don't know whether, um, there were any such thing as space and time before the Big Bang. But, on the other hand mathematicians and physicists are working on the question and it's a thing we hope to be able to answer some time. And George has had lots of interesting things to say about this too.
>
> *Smoot*: Right. It's a problem that I've been interested in because not surprisingly many people have asked this question and one of the hardest things that people — they just can't accept the fact there couldn't be time before the beginning. They — the idea that time doesn't go back forever is alienable and you try to give them examples like, you know, try and go past the North Pole and try to go North of the North Pole or something. You try and give those examples and it's unsatisfying for people even though you can understand that if you keep heading north, which is like going back in time, there comes a time when you are going forward in time and you can construct a Universe like that. But in fact there are lots of alternatives out there where going back in time is like a kind of random walk or something. There are a lot of people who are working on various models where there might have been something going on before our particular part of the Universe bubbled into a Big Bang and you don't know what the answer is and you know that the Big Bang is going to confuse. It's — it's like somebody torched the place and set fire to and the clues are very hidden after that but occasionally when you are experts in arson you can figure out whether it was burned by mistake or by accident and that's what scientists are trying to do they are trying to pose the question in the most general way, right. And right, even including making the most general laws in physics and see what kind of Universes you get and some of the things I think are quite successful and some are things like you have in the early days of quantum mechanics and the Copenhagen School. Some of the stuff makes a lot of sense and they are good rules and <u>some of it is just mysterious mumbo jumbo because nobody knows what is going on</u> and it will sort itself out.

When he talks about time here, Smoot is repeating an ill-conceived idea discussed by Stephen Hawking on pages 137–138 of *A Brief History of Time*, which is predicated on the existence of the Big Bang. Hawking's book has little bearing on reality as it does not discuss geometric cosmic time nor deficiencies in GR revealed herein. What George Smoot did get right was the underlined portion of the last sentence. In the same interview, John Mather provided an excellent description of modern science as a profession.

> We have to have a combination of confidence and caution. The person who is too confident is dangerous and the person who has no ambition is dangerous, so we have to have a mix of the things that are beyond what we can do but can still be proven, so this is what we do.

Given the theoretical ideas and empirical evidence presented in this book, it is reasonable to now state with high confidence that the Big Bang never happened, and in light of the revealed necessary correction to general relativity, never could have happened. There is no such thing as a spacetime singularity where the laws of physics break down; rather, in the case of extreme gravitational collapse, it seems certain that a bridge forms between remote regions of spacetime. If the Universe never existed in a prior state of extreme heat and density, it makes no sense for particle physicists to artificially create extreme states of matter for the stated purpose of studying cosmology. As plastics manufacturing exemplifies, things can be created in the laboratory that have nothing whatsoever to do with naturally occurring processes. Additionally, should the experiments proposed in *Sections 30–36* validate the related new ideas presented concerning quantum mechanics, nuclear physics and quantum gravity, a number of current scientific ideas, projects and proposals must be reconsidered and either altered or entirely abandoned. People are going to have to admit that they were mistaken and apply their precious expertise in new directions.

Human culture benefits from a sense of continuity, purpose and meaning. A culture lacking these essential features is bound to exhibit deterioration. At the American Association for the Advancement of Science Annual Meeting in February 2009, with the theme "Our Planet and Its Life: Origins and Futures," distinguished theoretical physicist and cosmologist Lawrence M. Krauss gave a lecture with this synopsis:

> I will describe how the revolutionary discoveries in cosmology over the past decade have completely changed our picture of the future of the universe, and of life within it.

The title of this talk was *Our Miserable Future*, reflecting the zeitgeist evoked by the current standard cosmological model and the conventional interpretation of the most recent astrophysical observations.[267] Following is a transcript of Krauss' monolog from a related press conference on 16 February, which included Alan Guth (M.I.T.), Krauss (Arizona State University), John Carlstrom (University of Chicago), and Scott Dodelson (Fermilab) discussing the state of cosmology. This is a perfectly accurate transcript of the "Stars of Cosmology I" *Scientific American* podcast that includes occurrences of repetitive speech.

> And, um, we have been living in the "Golden Age of Cosmology," as people say, and the question is, what will, what is going to happen in the near future and, and of course, we don't know. Ah, we're getting so close to threshold questions, fundamental questions about the Universe, that we may be at the limits of what we would call falsifiability — our ability to definitively rule out ideas maybe begun to be limited, because the, because the grandeur of the ideas that we're testing may become so great. — Inflation is, is really a remarkable idea, that, that, that is simple and beautiful. Right now it's an idea more than a model and it could be that we may end up with, with a, with observations that are completely consistent with, with inflation, but we may not be able to say for certain whether it happened or not. We, we may have to live with that. — But it gets worse. — The good news about the Universe is that as bad as it is now, it's going to get a lot worse, so you should enjoy it. And the future of the Universe is, it is based on what we now have been able to measure, completely miserable. . . .
>
> And these crazy ideas have suggested mainly to the, to a change in the nature of science. The most puzzling observation that has been made in the last decade is that the Universe seems to be full of this something called "dark energy" — empty space is full of energy. If you get rid of all the radiation and matter from the Universe, empty space still weighs something. But the crazy thing about empty space weighing something — well, there are many crazy things — well, it produces a gravitational repulsion, rather than attraction, so the expansion of the Universe is speeding up. But this stuff is so mysterious and inexplicable — completely inexplicable right now — that many physicists have been driven wild and mad (laughter) and, um, have changed what we may mean by "fundamental physics," by suggesting, for example, that the fundamental constants in nature are not really fundamental at all; they are accidental. They are an environmental accident. That there are many universes and we just happen to live in the one that has, that has the values it does because if you changed it a little bit then we wouldn't be living. Namely, the Universe is the way it is because there are astronomers who can go out and measure it. And, ah, that may sound like either a tautology or a religious statement, but it's neither. In fact, in honor of Darwin, it's almost like a kind of cosmic evolution. Kind of cosmic natural selection.
>
> …

> Now that has changed completely the nature of — if that's really true it means the future of science is very different, because if there are many universes and [in] each universe the laws of physics are different, then maybe we have to throw out fundamental ideas and, and the ability to make fundamental predictions in Nature and have to start talking about probabilities. If that's true, well, all hell breaks loose, I think, anyway (laughter). And then finally, the future of cosmology will get even worse.
>
> … (Carlstrom speaks after Krauss and then Krauss responds as follows.)
>
> It's certainly true that every time we've opened a new window on the Universe, we've been surprised. And the, the big — my biggest fear — and I'm willing to bet John here in front of reporters, is that, um, is that we will — we have made a remarkable discoveries [sic] in the last decade, (yeah) and we don't understand these things that we've seen — we don't understand dark energy, we don't understand a, a lot of this — we've discovered the nature of the Universe, but we don't understand why it is the way it is. And I'm concerned that we may — that experiment may have expired in terms of being able to fundamentally illuminate these questions, and we may rely on theory, and, and if you're a scientist, that's a dangerous thing to rely on. And uh, and so we may be at the threshold where we may require a new idea, and that's a lot harder.[268]

If the "crazy" Big Bang cosmological model and interpretations of astrophysical observations promising a "miserable future" are correct, then so be it; we will just have to live with it. However, if the model and the interpretations are actually incorrect, then the proposed corrections to the cosmological model put forward in this book should have a broad positive impact on the world beyond scientific specialists. Though perhaps subtly, the cosmological model has a systemic effect on human psychology and culture on a global scale because it defines perceived reality on the largest imaginable scale of space and time.

According to culturally ubiquitous and ancient ideas, the proverbial Devil, the purveyor of chaos and despair, attempts to achieve the downfall and destruction of humanity by deceit, trickery and illusion. Counteracting this dark power is the intangible, unestablishable Spirit of God, which illuminates the mind; the misleading dark illusion is made manifest and truth is brought to light. However, in order for this to occur, the ego must be subservient to the Creative Source that may bestow understanding. —

> Ask, and it shall be given you; seek, and ye shall find; knock, and it shall be opened unto you: [269]

Physicist Wolfgang Pauli, who was among the best scientific minds of the 20th century, believed that in order for science to progress, it needs to embrace a holistic view of reality that includes accepting the existence of phenomena that cannot be rationally understood. Because physics is limited to the study and understanding of the physical world, Pauli considered it to be an incomplete view of nature; there is more going on in the Universe that can ever meet the eye, be recorded by an instrument or be examined with the scientific method. Pauli thought of the study of physics as one path towards the greater aim of achieving a state of higher consciousness, which is the means of understanding these intangible things; others typically pursue the same aim with yoga, meditation or religion. He believed in the possibility of reconciling opposites: physics vs. psychology, metaphysical vs. natural science, intuition vs. logic.[270]

What the poet Blake called "Newton's Sleep," Pauli's close friend and confident, psychiatrist Carl Jung, defined in greater detail. He maintained that the advent of modern science had intellectualized the spiritual, portrayed the merely irrational as invariably malevolent, and thus deprived the spiritual world of visibility.[271] One has difficulty accepting an event as a spiritual experience or discussing such experiences among colleagues if there is a social consensus that such experiences cannot exist. Yet, science teaches us that consensus has no bearing whatsoever on the truth of a matter. "Everybody" can be completely wrong.

The APS *Guidelines for Professional Conduct* includes the following brief paragraph on the subject of acknowledging and correcting errors in theory, data or the interpretation of either.

> It should be recognized that honest error is an integral part of the scientific enterprise. It is not unethical to be wrong, provided that errors are promptly acknowledged and corrected when they are detected.[272]

This book has presented new theoretical ideas and considerable supporting empirical evidence implying a number of significant errors in modern conventional textbook physics and cosmology. Ethical behavior on the part of leading professionals in the theoretical physics and astrophysics communities requires prompt peer review and written criticism of its content that is readily available to the entire scientific community.

"I am not so unreasonable, sir, as to think you at all responsible for my mistakes and wrong conclusions; but I always supposed it was Miss Havisham."

"As you say, Pip," returned Mr. Jaggers, turning his eyes upon me coolly, and taking a bite at his forefinger, "I am not at all responsible for that."

"And yet it looked so like it, sir," I pleaded with a downcast heart.

"Not a particle of evidence, Pip," said Mr. Jaggers, shaking his head and gathering up his skirts. "Take nothing on its looks; take everything on evidence. There's no better rule."

"I have no more to say," said I, with a sigh, after standing silent for a little while. "I have verified my information, and there's an end."

– Charles Dickens, *Great Expectations*, Chapter 40.[273]

THANK YOU

I greatly appreciate that you have invested your valuable time in my ideas. Those with special talent in mathematical physics should be able to carry these ideas forward. Others may make an important contribution by promoting criticism. If you have enjoyed reading the book, I encourage you to periodically visit www.sensibleuniverse.com. There will be new information and opportunities for visitors as the Web site develops. In particular, I look forward to soliciting and posting professional criticism of this manuscript by leading authorities in the physical sciences.

A. SDSS RECOGNITION

Critical portions of this book have relied on the data acquired by the Sloan Digital Sky Survey (SDSS).

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The SDSS is managed by the Astrophysical Research Consortium for the Participating Institutions. The Participating Institutions are the American Museum of Natural History, Astrophysical Institute Potsdam, University of Basel, Cambridge University, Case Western Reserve University, University of Chicago, Drexel University, Fermilab, the Institute for Advanced Study, the Japan Participation Group, Johns Hopkins University, the Joint Institute for Nuclear Astrophysics, the Kavli Institute for Particle Astrophysics and Cosmology, the Korean Scientist Group, the Chinese Academy of Sciences (LAMOST), Los Alamos National Laboratory, the Max-Planck-Institute for Astronomy (MPIA), the Max-Planck-Institute for Astrophysics (MPA), New Mexico State University, Ohio State University, University of Pittsburgh, University of Portsmouth, Princeton University, the United States Naval Observatory and the University of Washington.

B. ACKNOWLEDGMENTS

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C. TRIBUTE TO HERMANN MINKOWSKI

The mathematical education of the young physicist [Einstein] was not very solid, which I am in a good position to evaluate since he obtained it from me in Zürich some time ago. – H. Minkowski

Youthful portrait of Hermann Minkowski (1864–1909)

Preface to *Raum und Zeit* [*Space and Time*] (1908)

The talk on "Space and Time", which Hermann Minkowski gave at the Convention of German Scientists and Doctors in Cologne, is the last of his ingenious creations. Unfortunately, it was not destined for him to finish the more detailed development of his audacious concept of a mechanics in which time is integrated with the three dimensions of space. Equally esteemed for his personal and professional qualities, the author was torn away from his loved ones and friends at the height of his life and creativity by a tragic fate on 12 January.

The understanding and enthusiastic interest that his talk had awakened filled Minkowski with inner content and he desired to make his interpretation available to a wider circle through a special published edition of his lecture notes. It is with a painful duty of piety and friendship that the editor's bookshop von B. G. Teubner and the undersigned do herewith fulfil the last wish of the deceased.

Halle an der Saale, Germany

20 February 1909

A. Gutzmer

– Translated and adapted from the German with the kind assistance of Dr. Martin Lades. –

D. ADDRESS BY DAVID HILBERT

David Hilbert (1862–1943) was one of the preeminent mathematicians of the 20th century. He grew up in Könnigsberg, where he also attended the University of Könnigsberg with his close friend, Minkowski. He spent the majority of his career as the Chair of Mathematics at Göttingen and made efforts to ensure that Hermann Minkowski was a member of the department. After Minkowski's sudden and unexpected death in January 1909, it is likely that Hilbert had exclusive access to Minkowski's papers. Hilbert's 1909 idea of the infinite-dimensional 'Hilbert Space' may well have been motivated by unpublished creative work originally conceived by Minkowski.

Königsberg, Fall 1930

The tool implementing the mediation between theory and practice, between thought and observation, is mathematics. Mathematics builds the connecting bridges and is constantly enhancing their capabilities. Therefore it happens that our entire contemporary culture, in so far as it rests on intellectual penetration and utilization of nature, finds its foundations in mathematics.

Already some time ago Galileo said, "Only one who has learned the language and signs in which nature speaks to us can understand nature."

This language however is mathematics, and these signs are the figures of mathematics.

Kant remarked, "I maintain that, in any particular natural science, genuine scientific content can be found only in so far as mathematics is contained therein."

In fact we do not have command of a scientific theory until we have peeled away and fully revealed the mathematical kernel. Without mathematics, modern astronomy and physics would be impossible. The theoretical parts of these sciences almost dissolve into branches of mathematics. Mathematics owes its prestige, to the extent that it has any among the general public, to these sciences along with their numerous broader applications. Although all mathematicians have denied it, the applications serve as the measure of worth of mathematics.

Gauss speaks of the magical attraction that made number theory the favorite science of the first mathematician — not to mention the inexhaustible richness of number theory, which far surpasses that of any other field of mathematics.

Kronecker compares number theorists with the lotus-eaters, who, once they started eating this food, could not let go of it.

The great mathematician Poincare once sharply disagreed with Tolstoy's declaration that the proposition "science for the sake of science" would be silly.

The achievements of industry for example would not have seen the light of the world if only applied people had existed and if uninterested fools had failed to promote these achievements.

The honor of the human spirit, so said the famous Konigsburg mathematician Jacobi, is the only goal of all science. We ought not believe those who today, with a philosophical air and reflective tone, prophesy the decline of culture, and are pleased with themselves in their own ignorance. For us there is no ignorance, especially not, in my opinion, for the natural sciences.

Instead of this silly ignorance, on the contrary let our fate be:

"**We must know, we will know**".

Translation by Amelia and Joe Ball.

Thanks to Ruth Williams of UC San Diego for posting this translation online.

http://www.math.ucsd.edu/~williams/motiv/hilbert.html

E. HUDF CORRELATION CALCULATIONS

Let δ be the length of a cosmological standard rod, chosen to be the average individual galactic diameter of a large population of galaxies as represented by one of the Fig. (8) redshift bins. We know that the value of δ is almost certain to be somewhere in the following decade range, where the upper bound is the estimated diameter of the Milky Way Galaxy measured in light years (*ly*).

$$10^4 ly < \delta < 10^5 ly \tag{122}$$

Apparent angular diameter is inversely proportional to distance; Eq. (13) yields Eq. (2) from

$$\theta \propto d^{-1} \quad \rightarrow \quad \theta \propto \left[\cos^{-1}\left(\frac{1}{z+1}\right)\right]^{-1} \tag{123}$$

Fig. (9) implies that the apparent angular diameter of the standard rod δ observed at a redshift distance of $z = 0.04$ is about eight arcseconds or ~3.8785×10^{-5} radian. The Euclidean circle applies; consequently the modeled distance represented by this redshift is determined by the empirical parameter δ.

$$d = \frac{\delta}{3.8785\times10^{-5}} \tag{124}$$

From Eq. (11), the cosmological latitude (ζ) of redshift $z = 0.04$ determines the relative distance to the cosmological horizon (about 17.7%) so the empirical parameter δ in conjunction with the SDSS observations shown in Fig. (9) also specifies the distance to the cosmological redshift horizon (H).

$$\zeta = \cos^{-1}\frac{1}{1.04} \approx 0.278 \qquad \frac{0.278}{\pi/2} \approx \frac{1}{5.65} \tag{125}$$

$$H = 5.65\cdot d = 1.4567\times10^{5}\cdot\delta \tag{126}$$

The average galactic diameter (i.e., standard rod) range in Eq. (122) yields the following range for H.

$$1.46\times10^9 ly < H < 14.6\times10^9 ly \tag{127}$$

As H correlates to a cosmological latitude of 90-degrees ($\pi/2$) and assuming H ~ 10 G*ly*, the effective radius of the Universe (R) is readily determined.

$$R = \frac{2H}{\pi} \approx 7\times10^9 ly \tag{128}$$

From Fig. (22), the volume of observable space (V) is π^2R^3, so Eq. (128) yields $V \sim 3\times10^{30}\ ly^3$. The HUDF shows about 10^4 galaxies in 10^{-7} of the sky (implying ~10^{11} galaxies for the entire sky), which is currently understood to be an accurate order of magnitude estimate for the total number of galaxies in the observable Universe (N). The quotient V/N yields the average volume of space occupied by a typical galaxy of the total population, given the average separation distance between neighboring galaxies.

$$\frac{V}{N} = \frac{3\times10^{30}}{10^{11}} \sim 3\times10^{19} ly^3 \tag{129}$$

This volume correlates to a radius of about one parsec (3.26 M*ly*). Accordingly, the average separation between galaxies according to the model and the above calculations is double this distance, or on the order of 10 M*ly*. This value is consistent with rough estimates of galaxy separation distances based on empirical observations within the Virgo supercluster where we find ~125 galaxies within a radius of ~20 M*ly*.[274]

EPILOGUE QUOTATIONS

It is our responsibility as scientists, knowing the great progress and value of a satisfactory philosophy of ignorance, the great progress that is the fruit of freedom of thought, to proclaim the value of this freedom, to teach how doubt is not to be feared but welcomed and discussed, and to demand this freedom as our duty to all coming generations.

– Richard P. Feynman, *The Value of Science* (1955)

Δ

I know that most men — not only those considered clever, but even those who really are clever and capable of understanding the most difficult scientific, mathematical or philosophic problems, can seldom discern even the simplest and most obvious truth if it be such as obliges them to admit the falsity of conclusions they have formed, perhaps with great difficulty — conclusions of which they are proud, which they have taught to others, and on which they have built their lives.

– Leo Tolstoy, *What is Art?* (1896)

Δ

We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances. To this purpose, the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

– Isaac Newton, *Principia: Book III: Rules of Reasoning in Philosophy* (1687)

Δ

We may always depend on it that algebra, which cannot be translated into good English and sound common sense, is bad algebra.

– William K. Clifford, *Common Sense in the Exact Sciences* (1885)

Δ

Advances are made by answering questions. Discoveries are made by questioning answers.

– Bernard Haisch, astrophysicist (c. 2000)

Δ

When I was starting out in mathematics, it seemed very important to prove a big theorem. Now, with more experience, I understand that it is new notions that are more important, for example, Alan Turing's new notion of computability, which I shall discuss today.

– Yuri Ivanovich Manin, *Talk on computability*, Northwestern University (c. 1995)

Δ

★ . . . The doctrine that the world was created is ill-advised, and should be rejected. If God created the world, where was He before the Creation? . . . Know that the world is uncreated, as time itself is, without beginning and end.

– Mahapurana (India, 9th century)

Δ

★ Every cluster of galaxies, every star, every atom had a beginning, but the Universe, itself, did not.

– Sir Fred Hoyle (1915 – 2001)

Δ

Creation is ongoing. – Lakota proverb

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>
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>>
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>> 2. the nature of the copyrighted work;
>> 3. the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and
>> 4. the effect of the use upon the potential market for or value of the copyrighted work.
>
> …the classic opinion of Joseph Story in Folsom v. Marsh, 9 F.Cas. 342 (1841):
>
>> [A] reviewer may fairly cite largely from the original work, if his design be really and truly to use the passages for the purposes of fair and reasonable criticism.
>
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